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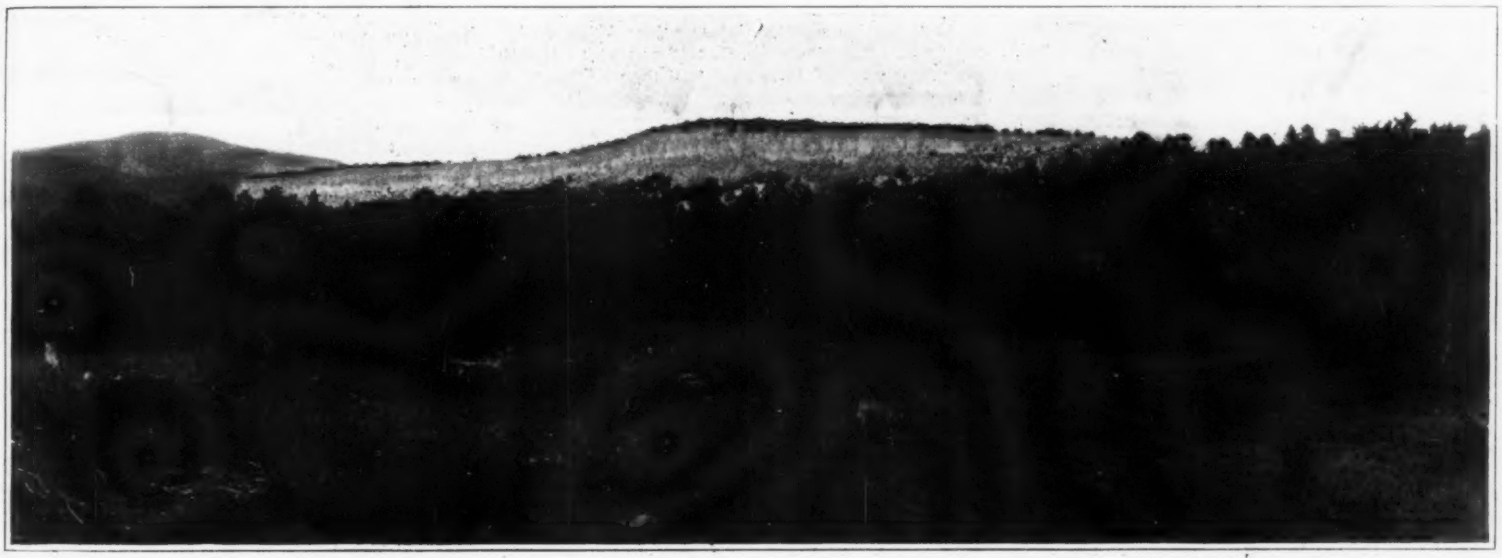
Navajo Hogan: The Primitive Hut is Modeled After the Cave Dwelling.

Navajo Hogan Near the Business Center of Albuquerque, New Mexico.



Distant View of Pu-ye Cliff Dwellings. The Ruins Extend Along the Face of the Cliff for About One Mile.

The Most Perfect of Existing Types of Pueblo Architecture, Showing Terraced Structure.

THE DAWN OF ARCHITECTURE. [See page 152.]

The Great Star Map—I*

The Team Work of the World's Astronomers

By H. H. Turner, D.Sc., D. C. L., F. R. S., Savilian Professor of Astronomy in the University of Oxford

The simpler name "star map" is here applied to the chart generally known as the "Astrographic Chart," because this latter conveys a suggestion of technicality which is absent from the project. What astronomers in different parts of the world are really about is the making of a large and much more detailed map of the stars than has hitherto been produced. The map is being made by photography; but though the word "astrographic" has been coined for use when photography is applied to the stars, the work does not involve much technicality that is not familiar to the users of an ordinary Kodak. In three details only does the work of the astronomer differ from that of the amateur photographer: he uses a much longer camera; he drives the camera by clockwork so that it may follow the stars; and he takes pictures at night instead of in the daytime. It may perhaps be added that he uses the light emitted by stars, instead of photographing objects by reflected light of the sun. But of these details more presently.

Let us first consider what is the nature of a map of the stars, as this differs somewhat in character from the maps of the earth's surface with which we are familiar. There is no question of finding our way, no question of delimiting property, no question of showing hills and valleys. A map of the stars is of a more monotonous character, being practically limited to showing the exact positions and the brightnesses of individual points of light. Maps of the stars may differ from one another in scale, in accuracy, and in completeness: In scale because we may show two given stars separated on the map either by a foot or by an inch, according to requirements; accuracy will have a tendency to be greater on the larger scale; and they may indicate either a few bright stars or many faint ones. We are familiar with the fact that there are only a few very bright stars, more of a degree less bright, more still fainter stars; and the increase continues as the luminosity diminishes, long after they have ceased to be visible to our eyes, no limit being reached even by the longest exposures given with our largest telescopes. Completeness then can only be a relative term. It is at present impossible to think of giving all the stars in the sky; we can only settle to give all those brighter than a certain fixed standard.

The earliest maps of the stars were probably made for astrological purposes; later they were required for the use of sailors. But through all the centuries so little had been done towards making accurate maps that in 1674, when there arose a question of finding the longitude at sea by observations of the moon and stars, it was pointed out by Flamsteed that no sufficiently accurate maps or catalogues of the stars were available. King Charles II., to whom this information was brought, was thoroughly alarmed at the state of affairs and immediately said that he must have the omission rectified. Thus was Greenwich Observatory established. When asked who was to take charge of the observatory, the king immediately replied that Flamsteed, who had pointed out the need of such an institution, was the man to put in charge. Modern observation of the positions of the stars may be said to have begun at this period. Greenwich took a great step forward half a century later, when Bradley was made the third Astronomer Royal and increased the accuracy of observation very considerably, so that his results have formed the basis of our knowledge of the positions of the stars to the present time. But Bradley and his successors for the most part confined their attention to the brighter stars, not concerning themselves with those much fainter than can be seen with the naked eye. There are two good reasons for this. In the first place, the number of stars required for the use of sailors is not large; indeed, sailors themselves use remarkably few, for only the brightest are suitable for observation by the small telescopes of their sextants. Indirectly, however, sailors depend upon the keeping of accurate time—Greenwich time is in use all the world over for determining longitude: and for keeping accurate time a much larger number of stars, called "clock stars," is required. These have had the first claim upon the attention of astronomers at our great observatories during a couple of centuries. A second reason for confining attention to these brighter stars arises from the limitations of instruments. The observations were generally made by watching the star cross the field of view, in which were certain spider lines for reference. Now these lines cannot be seen unless the field of view is illuminated, and a faint star is then lost in the illumination. In these days of electric light it is comparatively easy to adopt a new instrumental method, whereby the wires themselves (and not the background) are illuminated; they then appear as bright lines but are not sufficiently dazzling to obscure even a faint star, which can thus be observed as well as a bright one. But in former times this method had not been sufficiently developed and in any case the brighter stars were easier to observe. For these reasons therefore the fainter stars have not attracted attention until comparatively recently. One motive for studying them came with the discovery of the minor planets, which dates from the first day of the nineteenth century. It had been realized that there was a gap in the sequence of planets (as arranged in order of distance from the sun) between Mars and Jupiter. It was clear that there could not be any large planet in this position, for it would have been noticed; but there might be a small one, so search was made for it. The method of search was somewhat laborious. It was necessary to identify all the stars within a certain region in order that any strange body might be detected. It is now easy to accomplish this by taking a photograph of the region; but at the end of the eighteenth century no such compendious process was available; then the positions of individual stars were either patiently and laboriously measured one by one, or learned by the astronomer so that he could carry a picture of the region in his memory. In default of an actual material photograph he practically photographed the image on his own retina. It is astonishing to think how much was accomplished by this toilsome process. Not one only but hundreds of minor planets were discovered in this way, though not without difficulty and delay. Four were found at first in rapid succession and then came a long blank during nearly half a century, so that it seemed as though the number were complete: but though this view proved quite erroneous, it was only after a search of fifteen years that Hencke, an ex-postmaster of Driessen, was at last rewarded by another discovery. From that time the number has been extended almost continuously, so that we now know nearly seven hundred of these tiny bodies. From the circumstances attending the discovery and the subsequent observation of them has arisen one need for charting the places of the fainter stars. The easiest way to record the movements of these small bodies is to measure their distances from adjacent faint stars, and this is only satisfactory when we know the places of the stars themselves. This led astronomers to undertake the great work of charting the zone of the heavens called the Zodiac, in or near which all the planets move. Such an enterprise was started at Berlin early in the nineteenth century; another, initiated by Chacornac many years later was continued by the brothers Henry of Paris, who ultimately took the great step of employing photography in the work; and this led to the inception of the scheme we are now considering.

The introduction of the photographic method was at first fitful and tentative. Apparently the earliest attempts were made in America by the Bonds and by Rutherfurd. It is curious now to read of the difficulties in obtaining impressions of any but the brighter stars in the old days of wet plates. The wet plate of course was not nearly so sensitive as the dry plate; also it could only be exposed for a limited time before it dried up, and during such limited exposures only the brightest stars left an image upon it. Even the wildest hopes of these early pioneers in forecasting the future fell far short of what is now easily attainable: witness the following extract[1] from a letter of George Bond to the Hon. William Mitchell, Nantucket, dated from Cambridge (Mass.) July 6, 1857:

"As far as I am informed, the attempt to photograph the fixed stars by their own light has been made nowhere else up to the present date. The rumor of a daguerreotype of a nebula made in Italy some years since, was unfounded. . . .

"About seven years since (July 17, 1850) Mr. Whipple obtained daguerreotype impressions from the image of *a Lyræ* formed in the focus of the great equatorial and subsequently from *Castor*, thus establishing a simple but not uninteresting fact—the possibility of such an achievement. On these occasions a long exposure of one or two minutes was required before the plate was acted upon by the light. . . .

"Messrs. Whipple and Black recommenced their trials on other images (taken by the collodion process) in March of the present year and they are still in progress. . . . Could another step in advance be taken equal to that gained since 1850, the consequences could not fail of being of incalculable importance in astronomy. The same object *a Lyræ*, which in 1850 required 100s to impart its image to the plate, and even then imperfectly, is now photographed *instantaneously* with a symmetrical disc fit for exact micrometer measurement. We then were confined to a dozen or two of the brightest stars whereas now we take all that are visible to the naked eye. Even from week to week we can distinguish decided progress. . . . At present the chief object of attention must be to improve the sensitiveness of the plates, to which I am assured by high authorities in chemistry there is scarcely any limit to be put in point of theory. Suppose we are able finally to obtain pictures of seventh magnitude stars. It is reasonable to suppose that on some lofty mountain and in a purer atmosphere we might, with the same telescope, include the eighth magnitude. To increase the size of the telescope threefold in aperture is a practicable thing if money can be found. This would increase the brightness of the stellar images, say eightfold, and we should be able then to photograph all the stars to the tenth and eleventh magnitude inclusive. There is nothing then so extravagant in predicting a future application of photography to stellar astronomy on a most magnificent scale.

* * * * *

"P. S.—I find I have forgotten to allude to two important features in stellar photography—one is that the intensity and size of the images taken in connection with the length of time during which the plate has been exposed measures the relative magnitudes of the stars. The other point is that the measurements of distances and angles of position of the double stars from the plates, we have ascertained by many trials on our earliest impressions, to be as exact as the best micrometric work."

The letter is a remarkable one for the date. The three forecasts of improvement—increased sensitiveness in plates, larger instruments, and better climate—have all been realized within fifty years. There are two mountain observatories in California; there is a 40-inch lens, nearly three times the size of the 15-inch Harvard equatorial, at the Yerkes Observatory and two 5-foot mirrors represent an even greater advance; there has been also an enormous increase in sensitivness of plates. It was in this last particular that Bond failed to allow sufficient play to his imagination, as instead of an increase represented by one stellar magnitude we have more than ten times that estimate. But Bond's discernment was otherwise so great that this slight failure may be pardoned. His postscript shows that he realized even thus early the accuracy of the photographic method, and in this his judgment agreed with that of L. M. Rutherfurd, who set to work to measure his photographs systematically and soon found that they recorded the positions of the stars more accurately than his own apparatus would measure them. He used a micrometer screw and found, though he had provided himself with the best one available, that its errors were sufficiently large to prevent his doing justice to the photographs, and he turned aside from his original project to the construction of a better screw. Ultimately he made a screw so accurate that his attention was again distracted towards the completest possible test of its accuracy. This he found in the ruling of very fine lines close together on metal—several thousands within an inch—the result being what is called a grating, which can be used like a prism to spread out light into a spectrum. This work was so engrossing that Rutherfurd never seriously returned to his original purpose of measuring his photographs, but many of them have been measured since and have shown clearly how correct was his judgment of the accuracy of the photographic method. In spite of this accuracy, however, the inconvenience of the wet plate long delayed serious use of the method or the determination of star places. Photographs of the sun were taken showing the spots (requiring only a momentary exposure); measures of spot positions were made on these and found satisfactory. But a sun spot is an irregular object having no very definite position and does not afford a very severe test of accuracy; consequently this work failed to draw the attention of

* Reprinted from *Science Progress*.

[1] Memorials of William Cranch Bond, Director of Harvard College Observatory 1840-59, and of his son George Phillips Bond, Director of the Harvard College Observatory 1859-65, by Edward S. Holden (Lemcke & Beuchner, New York, 1897), p. 165.

astronomers to the full resources at their command.

The complete change in attitude came in a rather sensational manner on the appearance of the great comet of 1882. This comet, which was a very respectable object in the Northern Hemisphere, was much more magnificent in the Southern. The dry plate had by this time made photography easy and many members of the public who had recently become possessors of cameras essayed to photograph the comet; they found to their disappointment that the rotation of the earth carrying them and their cameras with it was sufficient to spoil their pictures. Thereupon, Sir David Gill, then H.M. Astronomer at the Cape, invited one of them to come to the Observatory and to strap his camera to the equatorial telescope (which was fitted with clockwork to counteract the earth's motion); immediately some beautiful pictures of the comet were obtained, and not only of the comet but of the surrounding stars. The number of stars shown on the photographs was indeed striking, and attracted widespread attention. The late Dr. Common of Ealing, who had been constructing telescopes for himself, without however any definite intention of using them photographically, immediately turned them to this new purpose and obtained some beautiful pictures of nebulæ. The brothers Henry in Paris saw the possibility of substituting the new process for the immensely laborious method by which they had been making their ecliptic charts; but in their case the change could not be made so easily, as their telescope had been made for visual use and could not immediately be used photographically. The difficulty arises from the existence of numerous colors in white light, the colors with which we are familiar in the rainbow. When looking through a telescope with the eye we use chiefly rays nearly yellow in color, while the photographic plate is sensitive to blue and violet. Now a lens cannot be constructed to focus all these rays at the same time and consequently for photography a new lens must be made which will focus the blue and violet light instead of the yellow. There are ways of avoiding this difficulty which may be briefly mentioned. In the first place if we use a mirror which brings the rays to focus by reflection, instead of a lens which combines them by refraction, no color difficulty arises. (It was for this reason that Dr. Common was able to use at once for photography the reflecting telescope which he had originally built for eye observation.) Secondly, modern improvements in the construction of photographic plates have made them sensitive to yellow light under certain conditions, so that visual telescopes can be used to take photographs if a yellow screen cuts out the unfocussed blue rays, leaving only those for which the telescope has been properly focussed. When a suitable plate is then put behind the screen, pictures of the moon and stars can be and have been obtained quite as good as those obtained with a telescope specially made for photography. But in 1882 this had not been realized and the Brothers Henry saw no way of using the new and promising photographic method but to make a new lens specially adapted for it. This they set about with great skill and determination. After a few trials on small lenses they at last succeeded in producing a photographic lens of 13 inches aperture, a veritable triumph of optical workmanship at that time. They were of course amateurs at the work. Admiral Mouchez, the Director of the Paris Observatory, gave them every encouragement and put at their disposal such resources as he had available; but their workshop was after all a mere shed. I have often heard Dr. Common speak with amusement of his visit to the workshop which had turned out to the admiration of the world the first successful photographic refractor —the modest building and the humble appliances were so surprising. We are reminded of the simple appartus with which great experimenters like Faraday have often achieved the most remarkable results.

It was the work of the lens thus produced by the Henrys that led directly to the inception of the project we are considering. The specimen maps of small regions of the sky which they soon obtained suggested the possibility of producing such maps for the whole sky. The work contemplated was no child's play. At least 10,000 maps would be required to cover the whole sky; and a labor of this magnitude was beyond the resources of a single observatory. Correspondence between Sir David Gill—under whose direction the comet photographs had been taken—and Admiral Mouchez, who had encouraged the work of the Henrys, led ultimately to the assembling of a great international conference at Paris in 1887. It was a remarkable meeting, the first of its kind in the history of astronomy; and it has shown the way for subsequent gatherings which have already made their mark upon that history. Conferences of a similar kind have since been held in 1889, 1891, 1896, 1900; and after a long interval in 1909. On all these occasions the French have acted as hosts and have discharged these duties with a cordiality and hospitality that has never failed to impress their colleagues from the most distant parts of the world. It would be difficult indeed to imagine a more pleasing center for our meetings than Paris or a nation more admirably adapted to play the part of hosts than the French; and they have been rewarded by an increasing success in the gatherings. At the last meeting it became clear that the assembly had developed from a mere collection of those interested in a particular project into an organization of the world's resources for the promotion of the astronomy of position. The physical side of astronomy has recently been organized on somewhat similar lines (profiting no doubt by the example provided), and the existence of these two great organizations will have a notable effect in economizing our labors in the future. In 1887 such an important outcome was scarcely anticipated: Attention was then concentrated on the immediate task before the assembly, which was a difficult one in every way. Astronomers from distant quarters of the globe speaking different languages, none of them with much experience of photography or of its possibilities but most of them with opinions more or less formed, met together to try to secure unanimity, not only in generalities but equally in small details. We need not be surprised at some of the results. The discussions were, to say the least of it, animated. There are no universal rules for conducting such business and astronomers of one country were not familiar with rules in use elsewhere. It interested Englishmen, for instance, who are accustomed to have resolutions moved by any one rather than the chairman, to learn that this was by no means a universal rule. On the contrary, the chairman of the first conference considered it part of his duties to move all the resolutions. After listening to a discussion, he took it to be his function to summarize the sense of the meeting in a resolution which he put from the chair and in favor of which he held up his own hand. Unfortunately for his success his was sometimes the only hand held up and the discussion was necessarily resumed. Another feature of such discussions on the Continent is a little strange to our insular prejudices but might perhaps be adopted by us with advantage. Occasions sometimes arise when the collision of contrary opinions produces considerable heat and there is an obvious desire on the part of two gentlemen (or even more) to speak at the same time. On such occasions the chairman rings a bell and declares the sitting intermitted for a few minutes. What has been public discussion can now be developed as private conversation. Gentlemen of opposite views who have been addressing one another excitedly across the width of the room may now rush together and arrive at a better understanding at close quarters. The effect of such an opportunity soon becomes evident when after a few minutes' interval the chairman again rings his bell—a calm has succeeded to the storm and not infrequently it is possible to crystallize out a resolution.

Let us glance at one or two of the matters which had to be decided in 1887. The first and most important was the choice of an instrument or instruments—for it was a preliminary question whether the same pattern should be used by all those co-operating in the work. This preliminary question, however, was soon settled in the affirmative. All were to use similar instruments; and now what were they to be? Should they be reflecting telescopes as used by Dr. Common, refracting telescopes as made by the brothers Henry, or refracting telescopes of a different pattern and more closely similar to camera lenses as advocated by Prof. Pickering of Harvard?

The advantages of the reflector were that it was cheap and that it existed. It is cheap because there is only one surface to be polished. Reflectors used to be made of speculum metal polished to a concave form; such were, for example, the great telescopes of Sir William Herschel and of Lord Rosse: nowadays instead of metal we use glass silvered on the face (not on the back as in a domestic looking-glass): but in either case there is only one surface to be prepared optically. Now with lenses there are two, four, or even more surfaces, all of which must be optically true. Moreover the glass must be entirely free from blemishes; if there is a fault in the substance of the glass which forms a mirror it is behind the reflecting surface and may not spoil the image but a fault in the interior of a lens cannot fail to produce its effect. Hence a lens is always much more costly than a mirror of the same size and the greatest telescopes in the world have always been reflecting telescopes. Lord Rosse's 6-foot mirror has not yet been surpassed in size, although Dr. Common and Dr. Richey have both succeeded in making mirrors of 5 feet and a mirror of no less than 8½ feet diameter is proposed, but the largest *lens* in the world is the Yerkes of 40 inches. Hence it could not fail to impress the conference of 1887 that the more economical instrument would be a reflector; moreover several such reflectors were already in existence and could, so it was hoped, be utilized without further expense. Thus at Oxford there was a reflecting telescope, which Dr. De la Rue had presented to the University Observatory, with which Prof. Pritchard hoped to take a share in the great project: If it were decided to use a different pattern of instrument his hopes would be disappointed unless he could obtain the money necessary to purchase one of the adopted pattern.

As regards the two forms of refracting telescope, the refractor and the doublet, that advocated by Prof. Pickering was the more expensive and the less known. In the light of our modern knowledge of its advantages (especially for the purpose of covering a larger area of the sky at once) it is very strange to find so little in support of it in the accounts of the discussion. It seems to have been put aside almost at once, in spite of the letter urging its adoption from Prof. Pickering. The chief reason for this was undoubtedly lack of information as to the accuracy with which plates taken by such an instrument would give the places of the stars. Specimen photographs taken by the brothers Henry with the other form of refractor had been measured and shown to be very satisfactory, but there was no corresponding information about the "doublet" as this third form of instrument is now usually called. Hence the doublet was put aside from the start and the choice was made between the reflector and the simple refractor.

The decision fell upon the latter. The choice has proved to be a wise one and it is satisfactory to remember that it was made without any acrimonious discussion. This was largely due to Dr. Common himself, who might perhaps have been expected to lay stress on the particular advantages of his own special instrument. His experience however had impressed him rather with its defects, especially with its uncertainty. This uncertainty is not due to the instrument itself so much as to our fitful climate: The reflector is so seriously influenced at times by air currents and changes of temperature as to be an instrument of moods and Dr. Common has accordingly compared it, somewhat ungallantly, to the female sex: He himself took the initiative in recognizing that the Conference should adopt for a work of such magnitude the more trustworthy refractor as made by the brothers Henry; this straightforward course had its due effect on the formulation of a decision. There are now therefore a score of such instruments scattered about the world, varying a little in non-essentials but all closely resembling one another in the size of the lens (which is 13½ inches in diameter) and in the focal length of the telescope (which is about 11¼ feet). The focal length is actually defined to be that which represents one minute of arc by a millimeter on the photographic plate; and this relation is so useful that in cases where a larger telescope has been built, the relationship has been recognized by making the scale exactly twice the size. Dr. Common adopted the same focal length (of about 11 feet 6 inches) for his excellent mirrors of 30 inches aperture; with these recently the beautiful photographs of comets have been taken and their power of discovering faint satellites has also been shown.

Another very important decision taken by the Conference of 1887 had a rather curious history. It arose from the ignorance, at that time, of the behavior of a photographic film and the fear lest it should shrink in drying or otherwise become distorted. Experience of photography generally—as for instance the taking of portraits or landscapes—was sufficient to show that such distortion was at any rate not large; but in astronomy we are concerned with very minute quantities and it was not known whether minute disturbances might not affect the relative positions of the images on the plate. Accordingly it was proposed to imprint upon each plate a series of accurately ruled crosslines called a *reseau*. They were to be photographed on the plate before development by exposing it to an artificial light behind a silver matrix (a flat plate coated with silver ruled with such lines); on development the lines appear together with the star images and if the film has shrunk during any of the processes of development, fixing, washing, etc., these lines will have shrunk sympathetically and will be no longer straight or at exactly equal distances as they were in the matrix. We have now learned that such shrinkage is so very small as to be negligible, at any rate for the purposes of our star map; indeed, even in the most minute investigations it is easier to neglect the shrinkage as accidental in character than to investigate it. Accidental errors can be obviated by taking another plate (or a number of other plates) and so far as our present experience goes the whole series of plates is very unlikely to be affected by any common or systematic error. Hence the function assigned to the *reseau* was due to a misapprehension and it has never been used for the purpose originally proposed. Fortunately it has been of immense value in another way. The lines have served as reference marks in determining the places of the stars with facility. To measure the distance between one image and another we might have used a long screw to carry a microscope from one to the other, but it is

better to compare the distance with a standard scale, using a screw to connect the stars with the ends of the scale; the latter method is to be preferred because it avoids the use of a great length of screw. Screws can now be made very accurately if necessary; Rutherfurd's work laid the foundations of such accuracy. But they are costly; their use over a large range takes time in turning the screw through many revolutions; and continual use is apt to wear away the screw and render it no longer accurate. Hence it is preferable to use the method of comparing with a scale; the *reseau* has practically supplied an accurate scale in both directions for the rapid measurement of star positions on the plate.

We may pause here to remark that the term "map" when applied to the present project must be used in a rather comprehensive sense. The scheme includes not only the pictorial representations on the plates or on any prints made from them but also the measurement of these plates and the publication of the measures of the individual stars. We can if preferred use a descriptive name for these measures. The printed books containing them are often called the Astrographic Catalogue as opposed to the prints which are the Astrographic Chart proper; but the whole project is really one and the same, although the usual process adopted in making a terrestrial map is here inverted. Surveyors of the face of the earth make careful measurements first and then plot them on a map and that was the method of astronomers before the days of photography. Now, however, we first take photographs and then measure them; but the project would be incomplete without full measures and charts. An illustration may be given of the risk involved in using one of these methods alone from the practice of Egyptian surveyors. They have been accustomed by centuries of tradition to enter their measurements of land in books without proceeding to make a map. It is only within the last few years that the Egyptian survey under Captain Lyons made maps for the first time of the landed property in Egypt; and when these beautiful maps were exhibited in Cairo thousands of landowners saw their property thus represented for the first time. When the maps came to be made the disadvantages of the old plan soon became apparent; some pieces of land had been recorded twice over while others had been omitted altogether. We can readily understand how this can happen in mere numerical records, though it is not so easy to understand how some individuals became reconciled to pay taxes as an annual consequence twice over; that some should have failed to resent their escape from taxes altogether is more intelligible.

(To be continued)

Practical Aspects of Printing Telegraphy—VI*

An Inventor on the Difficulties to be Encountered and the Way to Overcome Them

By Donald Murray, M.A.

Continued from Supplement No. 1860, page 135

KEYBOARDS AND KEYBOARD OPERATING.

With code and cipher messages it is absolutely essential that the operator shall keep his eyes fixed on the message all the time that he is sending, if he is to work rapidly and accurately. With the Morse key and sounder it is an easy matter for an operator to keep his eyes on the copy. With a typewriter keyboard, on the other hand, it would appear at first glance to be very difficult to work without looking at the keyboard. Experience has shown, however, that there is no real difficulty, and that in one month, with proper training, an operator can become an expert in "touch writing" on a typewriter keyboard. That is to say, he can learn within a month to operate rapidly and accurately on a typewriter keyboard without taking his eyes off the message. Code and cipher messages are then as easy to transmit on typewriter keyboards as on the Morse key, with the advantage that a single stroke on a key sends each character.

The same difficulty has been experienced in connection with the use of the ordinary typewriter in telegraphy, and also in using certain Morse transmitting keyboard machines. The typewriter companies long ago discovered the value of "typewriting by touch," and all the record breaking "typists" work in that way. Linotype operators have also discovered the advantage of this method of working. Some years ago it was noticed in New York newspaper offices that certain linotype operators (on piecework) were making considerably higher wages than their fellows. It was discovered that they had learned to operate the very large and complicated linotype keyboard of ninety characters without taking their eyes off the copy. Knowledge of the method soon spread, and "touch operating" on linotypes is now quite general. Typewriter keyboards are much less formidable. On the piano, of course, playing by touch is essential, and it is much more difficult than on a typewriter. On the latter it is merely a question of systematic instruction and training on the lines long ago found necessary in piano playing.

After some months' practice in this way, operators become extremely rapid and accurate. The author has seen 101 successive average British messages of 20 words perforated on a keyboard without a solitary error, and that at the high speed of 90 messages an hour. This is over 2,000 words per hour of complicated matter with many figures and strange words and addresses and personal names. The operator had at the same time to sign the messages and number the perforated tape.

The best operators are those whose sending becomes purely mechanical. Some men will use the Morse key and talk to you at the same time without making a mistake in the message they are sending. Others can whistle a tune and keep time with the "sticks," while punching a message on the Wheatstone puncher, and the perforated message will be free from errors. Operators have been known to work for a whole day on the Morse key without making a single mistake. When this stage of automatic perfection has been reached the operator becomes valuable, especially in the case of printing telegraphs. Such skill reduces the number of errors and of corrections and inquiries, and it is these corrections and inquiries that reduce the output of a telegraph system so much. Every such correction or inquiry means a loss of time on the average equal to the time of transmitting half a message, and more in those cases where the sending operator has to stop to look up the previous message to answer the inquiry. As an illustration of how automatic the work of sending messages becomes, a case was mentioned in the *Telgraph Age* of an operator

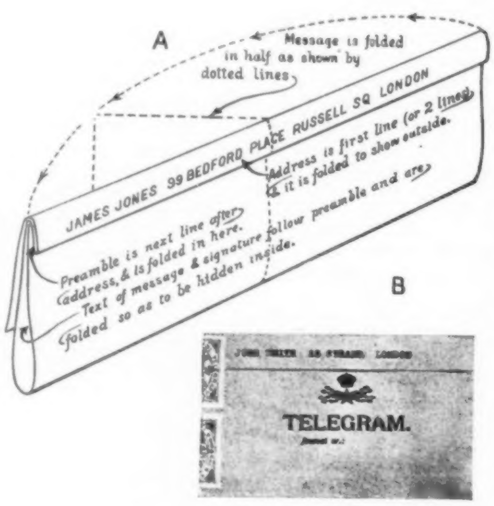


Fig. 3.—*A* Shows the Murray Printing Telegraph Method of Folding Telegrams so as to Dispense With Envelope. *B* Shows a Message Completely Folded and Sealed With a Couple of Adhesive Telegraph Stamps Used for This Purpose Only. The Advantages are Saving of Cost of Envelopes and Saving of the Time and Labor of Addressing Them.

in an American telegraph office having received the news of Lincoln's assassination over his wire without noticing it. He wrote it out and the news was posted up outside the telegraph office. A great crowd assembled. The telegraph operators were surprised, and on inquiring what the crowd was about learned that Lincoln was shot. The operator who had received the message, had received it mechanically, and had been entirely unconscious of the substance of the telegram he had written down. That sounds incredible, but it is no surprise to telegraph operators, and it is no surprise to highly skilled shorthand writers. It is exactly in accord with their own experience.

CONTRACTIONS.

With the Morse key an operator can use contractions in sending, because the receiving operator can easily write out the words fully on a typewriter. In the case of a printing telegraph this cannot be done, and if a word is sent over the line in a contracted form it will be printed in the same way. In America contractions are very freely used by operators, and these contractions have presented some slight difficulties to printing telegraph inventors in the United States. In Press messages contractions are also very freely used, and in Press messages to be sent over long ocean cables contractions have been developed into a fine art. All that a printing telegraph can do in such circumstances is to record the contractions.

ENVELOPES AND ADDRESSES.

On the Continent of Europe telegrams are not put in envelopes. They are folded and sealed and sent out in that way. In Germany the address has to be inserted in a special place in the middle of the top of the form. As the preamble comes before the address (in accordance with the terms of the International Telegraph Convention), the preamble has to be printed first, then the address, in Germany, above it, and afterward the text below it. With a tape printing telegraph like the Hughes, it is easy to put the address at the top, or on the back as in France; but with a page printing telegraph, if it is to work automatically, there cannot be any turning back to put the address in the middle of the top of the message form, and it is quite impossible to print the address on the back as required in France. Fortunately, in the case of the Murray automatic system as there is a receiving tape on which the message is recorded as perforations before it is printed, there is no difficulty in turning back by hand and printing the address where wanted, without interfering with the reception of the signals over the line. This is the arrangement adopted in Germany with the Murray automatic system, but there is undoubtedly loss of time when the automatic line and page feeds are not fully employed. In any case with a direct-printing page-printer turning back is not possible, and the message must be printed straight ahead as received. Page-printing saves time and labor; but the use of envelopes has a number of drawbacks. With the message folded so as to show the address only, as on the Continent, no envelope is needed, and therefore there is no loss of time and labor in addressing the envelopes and there is no risk of error in copying the addresses on the envelopes. Also the cost of envelopes is a considerable item. In Great Britain, for instance, 90 million envelopes are required for telegrams every year. Doing without envelopes would therefore save a considerable sum; but in Great Britain there are a large number of registered addresses, and these compel the writing out of the full address. In many cases, though, the more important registered addresses are printed ready on envelopes. The author devised a method of folding messages to suit page-printing telegraphs (see Fig. 3).

In this arrangement the address is transmitted first and then the preamble. This gets rid of any necessity to turn back, and the message can then be folded so as to show the address only. The conditions, however, are very complicated and in a case of this kind where there are so many conflicting considerations government departments are slow to move. Up to the present the new system of folding has not been used in England or Germany, but it is used in connection with the Murray automatic system in Russia, Sweden, and Norway. It is suitable for any page-printing telegraph, and it appears to be the only possible way of doing without an envelope in the case of messages received on a direct-printing page-printing telegraph.

MECHANICAL DIFFICULTIES.

THIS record of printing telegraph troubles may be conveniently brought to a close by some reference to the mechanical difficulties arising from the special mechanical problems that have to be solved by the inventors of printing telegraph machinery. Telegraph instruments belong to the class of controlling machines which are of necessity composed of locks, valves, and other ratchet mechanisms. These are the most unsatisfactory of all the kinematical elements, because they do not slide or roll; they strike. Also, their bad character is not improved by the facts that

* Paper read before the Institute of Electrical Engineers.

they have almost invariably to be operated by springs, that there is serious wear, and that there are numerous screws and pins which tend to work loose under the continual knocking and vibration inherent in such machines. The theoretical conditions are, in fact, so bad that the satisfactory service obtained from these machines is a matter of surprise. Success has been achieved as the result of attention to a number of practical details. One or two of the most important of these points may be conveniently illustrated by reference to the best known machine of this class, namely, the modern typewriter. A quarter of a century of experience has taught typewriter manufacturers the essentials for success. In the first place, it is a difficult thing to take a screw out of a modern typewriter. Quite a strong wrench with a screwdriver is needed. The screws have been driven absolutely tight home. The screws will also be found to fit well. There are no loose wobbly screws in a good modern typewriter. That is one essential point also in all telegraph machinery. Using only well fitting screws and driving them fast home are elementary and commonplace precautions, but printing telegraph inventors have suffered more from loose screws than from any other single mechanical defect. Another point to be noted about a modern typewriter is the generous size of the springs, and the avoidance of flat springs. Wherever possible steel piano wire springs are used in preference to any other kind. They are also made as large as possible, and there are no sharp bends in them. By using springs ample in size the strain put on them in working is far below their limit of elasticity, and springs are then as satisfactory as any other kind of mechanism. This also is an obvious and elementary point, but it is continually being disregarded by mechanics and inventors. There is also the question of the degree of accuracy required for various parts. Some parts have to fit finely to 1/10,000 of an inch, and other parts, on the other hand, must have plenty of "air," as the Germans say. The fit must be quite loose. In printing telegraphs as much trouble has been caused by fits being too good as by their not being good enough. Only one other point need be considered. In consequence of their nature, ratchet mechanisms must wear rapidly if they come frequently into action, as they have to do in telegraph machines. The expression "ratchet mechanisms" is used here in the widest sense, to include not only ratchets and pawls, but also valves, electric contacts, and similar mechanisms. There are two remedies. The first is to make the striking surface as large as possible, and of the most refractory materials possible. The second remedy is to make the parts quickly interchangeable, and to provide plenty of cheap spare parts. In a typewriter, for instance, all the wearing parts are interchangeable, and new parts can be quickly and cheaply inserted.

So far as springs and screws are concerned, elementary precautions can be adopted from the outset, but it is not possible to say offhand which parts will wear well in a printing telegraph, and which will wear badly. Only prolonged trials in practical work can develop the weak points, and even when the weak points are known it is not practicable to provide the abundant and cheap supply of interchangeable spare parts until the apparatus has been standardized, and

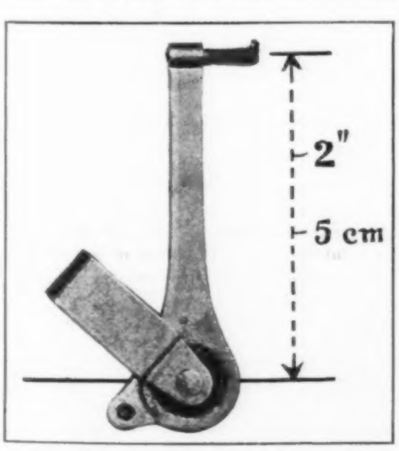


Fig. 4.—Typebar From Murray Automatic High-speed Printer. It is Exceptionally Short and has Ball Bearings.

the apparatus cannot be safely standardized until it has been in use for at least two or three years. That puts the printing telegraph inventor in a very difficult position, and it explains why it takes years to develop a printing telegraph up to the stage of practical commercial success. No doubt the telegraph engineer of the future will be able to sit down and design and calculate out a printing telegraph complete and perfect in every detail for any given purpose, just as engineers now design steam engines or electric motors, but it will be a good many years yet before the art of printing telegraphy reaches that degree of perfection.

THE MURRAY PRINTING TELEGRAPH SYSTEMS.

In order to illustrate some methods by which the foregoing difficulties have been more or less overcome, the following account is given of the Murray printing telegraph systems. The Murray automatic system has been described in the paper on "Setting Type by Telegraph,"* and a brief reference only will therefore

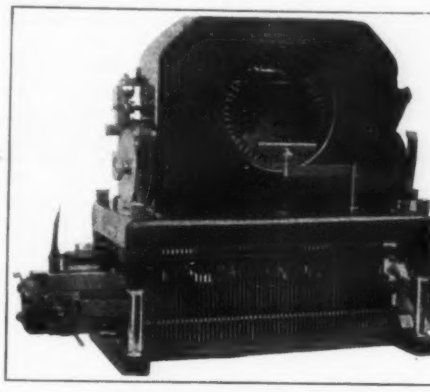


Fig. 5.—Front View of the Murray Automatic Printer Fitted With the Murray High-speed Typewriter. Speed, 1,200 Letters per Minute.

be made to it, most attention being devoted to the new Murray multiplex page-printing telegraph, of which no description has yet been published.

It may be explained, in the first place, that the Murray printing telegraph systems form a complete printing telegraph organization, and that they comprise—the Murray automatic page-printing telegraph, and the Murray multiplex page-printing telegraph.

The two systems, the Murray automatic and the Murray multiplex, have been designed to work together as one whole, the automatic system being best suited for long lines, and the multiplex for lines of average length. The two systems are in a sense complementary to each other. Many of the instruments are the same in both systems, and are interchangeable, the same alphabet or code of signals—the 5-unit Baudot—is used in both, and the perforated tape is the same in both systems, so that a perforated tape message may be transmitted either over a Murray automatic or a Murray multiplex circuit, and it may be reproduced and retransmitted at the receiving station on either system. An important point is that the same keyboard perforator is used on both systems. The standard typewriter arrangement of the keys is followed on the keyboard, and the same characters are used in both systems.

In the Murray automatic system, the messages are first perforated on a strip of paper tape in the Baudot 5-unit alphabet. The perforated tape is then used to transmit the messages by means of an automatic transmitter working on the principle of the Jacquard loom. The speed of transmission of the signals is from 100 to 180 words (600 to 1,080 letters) a minute, and at the receiving station the arriving signals are recorded at the same speed as perforations in a second paper tape, which is an exact replica of the transmitting tape. This reproduced tape at the receiving station then serves to operate an automatic typewriter somewhat on the principle of a mechanical piano. The telegraph line is worked duplex, giving one transmission in each direction simultaneously on the one wire. The received messages are printed in Roman type in page form, at speeds ranging up to about 200 words a minute (20 letters a second). The keyboard perforator for preparing the transmitting tape was described and illustrated in the paper already referred to. The automatic transmitter and the receiving perforator were also described, and there has been no substantial alteration in the construction of these instruments, although there have been many improvements in detail. In the automatic printer a great improvement has been made by the construction of a high-speed typewriter specially designed by the inventor of the system to suit the automatic selecting mechanism. The essential feature of this typewriter is that the typebars are very short, only 2 inches long (50 millimeters) from the pivot to the type. This insures extremely high speed. It is the shortest typebar ever put into a typewriter, the average length of typebars in typewriters being from 3 to 4 inches (75 to 100 millimeters). As the moment of inertia varies as the square of the length of the typebars, the gain in speed with typebars only 2 inches long is from 2 to 4 times. The typebars are also provided with ball-bearings, to insure free movement and permanent alignment. The illustration in Fig. 4 shows one of these typebars full size. The typebars being so short, it was necessary to arrange them in a complete circle in order to get room for the required number of 51 characters. As it was very desirable that the operator should be able to see the printing as it proceeded, the circle of type had to be arranged in a vertical plane. Key levers were omitted, as the inertia of key levers interferes with high speed. There are no other special features beyond the fact that the machine is built with unusual strength to stand the strain of the high speed. Fig. 5 is a front elevation of the complete printer, the upper part being the new special typewriter.

Fig. 6 is a back view of the printer.

In a typewriter, or in a page-printing telegraph, there are four motions of the paper as follows:

Letter feed—Short horizontal movement (one letter).

Line-feed—Long horizontal movement (about 60 to 70 letters).

Column-feed—Short vertical movement (one line).

Page-feed—Long vertical movement (one page or message form).

In the Murray automatic printer, the letter, line, and column feeds are entirely automatic, but the page-feed is manually operated, this having been found sufficient for present requirements. The maximum speed that has been reached on this printer is 250 words a minute (25 letters per second). The speed might perhaps be pushed up to 300 words a minute (30 letters per second), but the wear and tear would probably be great at speeds exceeding 200 words a minute. Typewriter companies often claim very high speeds for their machines, but it may be accepted as a fact proved by experience that no hand-operated typewriter on the market to-day will continue to do satisfactory work at a speed greater than 120 words a minute (12 letters per second), and for most typewriters the limit may be taken as 100 words a minute.

In order to prevent interruption of traffic by any stoppage of the apparatus, it is necessary to have reserve machines. With an automatic system this means duplicating the whole of the apparatus. The result is that the Murray automatic system is very expensive, costing at present about £1,200 ($6,000) per circuit, exclusive of royalties. This is a very serious handicap on the use of the Murray automatic. If manufactured in large quantities the cost would come down to about half this amount, but under present telegraph conditions the field for a printing telegraph of this kind is not sufficiently large to require large quantities of the apparatus.

Taking the four factors already referred to, namely, saving of time, labor, line, and office equipment, the Murray automatic system shows to advantage only in respect of saving of line. The cost of office equipment is greater than with the Murray multiplex, there is less saving of labor than with the multiplex, and there may be loss of time if the working arrangements are not good. This is specially the case if the system is worked at a high speed to carry heavy traffic. The working organization in this case must be first-class, or there will be a great reduction in the carrying capacity of the system. On long lines, 1,000 miles

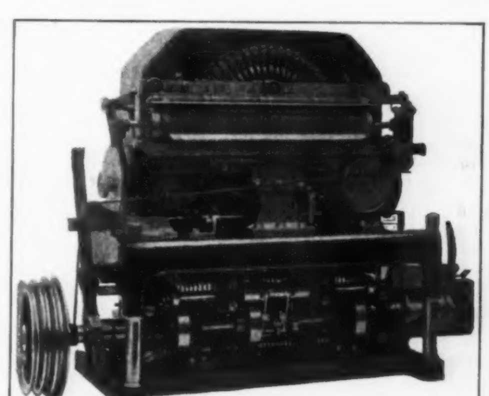


Fig. 6.—Back View of the Murray Automatic Printer With High-speed Typewriter.

and over, the saving of time and labor are of much less importance than increase in the carrying capacity of the line, provided always that telegraph traffic is growing rapidly so as to render increase of carrying capacity important. This is the case, for instance, in Russia and other new countries (Russia is practically a new country, Asiatic Russia, at any rate). It is in such conditions that the Murray automatic has decided advantages, as follows:

* *Journal of the Institution of Electrical Engineers*, Vol. 34, p. 555, 1905.

1. The alphabet or code of signals that it employs, and the manner of employing it, result in less signalling time per letter than in the case of any other system. The ratio is approximately 5 for the Murray automatic compared with 6 for the Murray, and the Baudot multiplex systems, and 8 for the Morse alphabet. This is an advantage of 20 per cent over the multiplex—an important matter on long lines. The advantage over the Morse alphabet is about 60 per cent.

2. Synchronism is not employed, only isochronism. That is to say, phase is of no importance, but the speed must be right.

3. Governing or control of speed is very quick, so that the right speed is obtained in half a second, and is re-established in half a second if it is momentarily thrown out by a line disturbance.

4. The Murray automatic apparatus is simple—much simpler than any multiplex system.

5. It works very well through the simplest of all repeating stations, namely, the Wheatstone duplex.

6. It works very well and easily with the duplex balance, even on very long lines.

As an illustration of the last point, it may be mentioned that the Murray automatic system is being worked duplex between St. Petersburg and Omsk in Siberia, with three Wheatstone duplex repeating stations at Riazan, Samara, and Tschellabinsk. The total length of the line from St. Petersburg to Omsk is about 2,400 miles (3,800 kilometers). The wire is iron, and the maximum speed with the Murray automatic is about 60 to 65 words (360 to 390 letters) per minute. The Wheatstone speed on this line is less than 40 words (240 letters) per minute. Of course, on such a long line there are often periods when it is only possible to work simplex, but that duplex working should be commercially practicable on such a circuit is remarkable. Obviously on such a line, with growing telegraph traffic, the one pressing question is increase of the carrying capacity of the line. Saving of time, labor, and office equipment are quiet subsidiary.

It will be noticed also that the advantages just enumerated are chiefly advantages for working over long lines. Hardly any of them are of importance on short lines. On lines of moderate length, time and labor saving are the all-important factors, and line saving is quite subordinate. On such lines no automatic system can save so much time and labor as a multiplex system. The splitting up of the line into from four to eight channels greatly facilitates the handling of traffic. There is less delay on messages, while inquiries and corrections are quickly obtained because of the numerous channels over which inquiries can be made. The speed of each channel being comparatively low, one operator on each sending channel can perforate, tape, and attend to his own automatic transmitter. That saves labor compared with the automatic system. Also at the receiving end of the line, the speed of each channel being low, 30 to 50 words a minute, the printers can print direct, and can be made entirely automatic in their actions, thereby saving labor, because one receiving operator can then receive and check as many as 150 messages an hour. On the other hand, on a long line it is not possible to get a number of multiplex channels. Hence on long lines the multiplex loses its chief advantage over the automatic system, and the advantages of the automatic system, already mentioned, then predominate.

On lines not too long to prevent a number of channels being obtained with a multiplex system on one line, the multiplex has the advantage that it can give simultaneous independent channels of communication between several towns connected by a single telegraph wire. This is an arrangement of great practical importance in the case of several towns, none of which alone can keep a telegraph line fully occupied. With an automatic system such an arrangement is not possible. With the automatic system messages may be retransmitted automatically by the received type, so that various centers can be connected up in this way on one line, but this would only be practicable on long lines connecting important centers. The Murray multiplex, however, now possesses this advantage of being able to retransmit messages from perforated receiving tape.

(To be continued.)

Logistics—II*

By Major William C. Bartlett, U. S. A.

Concluded from Supplement No. 1860, page 131

All great commanders have been most careful of the supply and equipment of their armies. Cæsar was always provided with a month's provisions for his troops, each soldier carrying twenty-five pounds of wheat, the meal ration at that time for fourteen days. Wellington flattered himself that if he was not a great general, still he had learned to be a good commissary, and Napoleon's remark, "an army crawls upon its stomach," shows he fully appreciated the question of subsistence. The consequence of neglect in this essential matter is shown clearly by the suffering and misery entailed upon the British troops in the Crimea by the failure of their commissariat, as well as by the wretched condition to which the Russian army in Turkey was reduced in 1878, when a St. Petersburg journal contained a letter, saying: "We are dying of famine is the cry of the whole army. The preserved meat distributed to us is in such an advanced state of decomposition that not only is it unfit for food, but to avoid an epidemic we have been compelled to bury tons of it." One of the results of this was the terrible outbreak of typhus fever at San Stefano in May, 1878, where 50,000 men, or 45 per cent of the entire force, was in the hospital at one time.

The detail of the subsistence stores furnished the German army are too complicated to be thoroughly ascertained from the means of information at hand. The Germans lived partly on the country, partly by the capture of provision trains from the enemy, and partly on the supplies from the magazines and those forwarded to each corps by the district with which it was connected by rail, and yet in some instances, says their official report, the supply of subsistence was deficient, and in others the regular ration was not issued. To give a faint idea of the quantity of food needed for such a multitude of men it will be sufficient to state that the one army of 150,000 troops investing Paris in the beginning of September, 1870, required 400 tons of food a day. Should the Germans not have been victorious, what would have been the result?

The details of ammunition and ordnance supply are not less wonderful. Three hundred and sixty-two thousand, six hundred and sixty-two rounds of field-artillery ammunition and 30,000,000 small-arms cartridges were expended during the war. Each army corps was followed by 243 artillery and 84 small-arms ammunition wagons, and the weight of siege material originally sent to Strassburg alone was 92,400 tons, which quantity had to be increased. This siege, although the greatest, was only one out of eighteen that took place in the campaign.

The average number of horses in the active German army from August, 1870, to March, 1871, was 226,000. Allowing ten pounds of grain a day to each animal (a short feed) we would have 2,260,000 pounds, or 1,130 tons, of forage required each day. Much of this came from the surrounding country, but great quantities had to be furnished from the magazines. The number of officers and men sent from the *ersatz*, or supernumerary force, to the German army to replace casualties, etc., was 222,782; the number of horses 22,012. The stream of war, however, does not flow altogether in one direction—there is always a returning eddy of sick and wounded and prisoners. Of the former there were 240,426 taken back to Germany; of the latter there were 383,841 sent there to be fed, housed and guarded.

Vast as is the business side of modern war, there is no single detail of it that can safely be omitted or attended to in a slipshop manner. Capt. Maude, R.E., writes: "The statement is made that 42,000 Germans, or 1,257 more than the total loss from wounds and sickness, were sent to the hospitals with sore heels, caused by an inferior boot." Wellington knew better than this, his theory being: "The first requisite of a soldier is a good pair of shoes, the second a spare pair of shoes, and the third an extra pair of shoes."

From what has been here stated, some conception may be formed of the enormous quantity of wheeled transportation that accompanies an army upon the march, the protection of which must be the first care of the commanding general, who, Sir Edward Hamley says, "probably directs a hundred glances, a hundred anxious thoughts to the communications in his rear for one that he bestows on his adversary's front."

The length of a Prussian Army corps, comprising 42,512 men, 13,802 horses, 90 guns and 1,285 carriages, has been found to be twenty-seven miles, eighteen miles of which were taken up by combatants and nine by train. On account of its length of troops in column, and of the vast tail of vehicles added to it, armies are, when possible, always directed upon several different highroads, between which it is important that there should be lateral communicaion, one, and sometimes two, corps taking a road.

An army marches slower in proportion to its size. A division by itself can go two and one-half miles per hour, while a corps can seldom make more than two. The reason of this is, that if the column closes up every night when halted the rear will have several miles to go after the advance is in camp. In like manner, when starting in the morning, the front of the column will be some distance on the road before the rear breaks camp.

The minute directions necessary to the achievement of effective and well-timed route or strategic marches are ordinarily little thought of. A memorandum of subjects to be included in orders for marches, as given in Morcus, contains twenty-three paragraphs, each on a different matter, and does not include such details as are fixed by general regulations at the beginning of a campaign. The most rapid continuous march of a large army on record was in 1805, when the Grand French Army, of three *corps d'armée*, broke up its camp at Boulogne in the early part of September, and in twenty-five days reached the Rhine, 400 miles away, having made an average of sixteen miles a day. It moved by divisions on three roads. Napoleon told Jomini that his system was "to march twenty-five miles, to fight and then to camp in peace."

The necessity of subordinate commanders following strictly the routes prescribed for them is well exemplified in Napier's Peninsular War. On the 18th of November, 1812, during the retreat from Burgos, the English army was to draw off before daylight from its position on the Huebra in face of the French. Wellington knew that the main road was impassable from the overflowing of a watercourse which intersected it, so he directed the divisions by a longer, and, as was thought, more difficult route. His division commanders consulted together and concluded that Wellington did not know his business, so they took the main road. When dawn appeared Wellington galloped off to search for his army and found it blocked up on the main road by the flood. He finally managed to draw his troops off in safety, although another gully running across the only road he had left was filling up so rapidly with water that the rear guard had to pass it man by man on a fallen log. Fortunately Marshal Soult was out of provisions and did not pursue in force.

When the march is preliminary to an engagement, the columns should be disencumbered of baggage, except rations and forage for one or two days and reserve ammunition; the trains being formed into one body prepared to pack when ordered. The columns advance upon all the roads leading to the enemy's position, which are within deploying distance of each other. Nearing the enemy, these columns subdivide into bodies of not less than a brigade and strike out for themselves routes as direct as possible to their places in line, pioneers clearing the way where necessary.

In a forward movement the advance guard of an army is the stronger; in a retreat the rear guard. The size of each is determined by the strength of the body they protect, the nature of the country and the quality of the enemy. Their distance from the main body varies, the one with the length of the column it guards, the other with the length of the baggage train. Advance guards clear away all small bodies of the enemy's light troops in their front, and in case of an attack in force they hold their position until the main body has time to deploy. The rule, as now laid down, is that advance guards should not bring on general engagements except by the order of the commanding general, but since the introduction of smokeless powder and the increased tactical mobility of artillery, I would venture to suggest that it may be of the highest importance to have an able officer always with the advance guard of an army, fully empowered to bring on a general engagement whenever he finds it possible so to do on ground clearly disadvantageous to the enemy. Either the German commanders had such instructions in 1870-71, or they didn't care a rap for the rule as laid down. The work of a rear guard is best accomplished, not by fighting, but by threatening to fight. When closely pressed advantage should be taken of some strong position to make a stand long enough to cause the enemy to hold and deploy his columns. Such actions as that

*Journal of the Military Service Institution.

of Gen. Cranford on the Cou, where, in command of Wellington's rear guard, he made a decided stand in a disadvantageous position with 4,000 infantry, 1,100 cavalry and six guns against the whole of Marshal Ney's *corps d'armée*, are due to ambition gone mad.

Too much attention cannot be paid to the subject of marches, both as to their conduct and practice. If it be true that the general who at a given time can have the greatest number of troops in the best condition for fighting at a given point is bound to be successful, then victory must, to a great extent, reside in the legs of the soldier. Gen. Wolseley writes: "Let me see two armies on the march and I believe I can tell you the respective fighting value of each." The fitness of troops for the final struggle when they at last meet their enemy must ever depend greatly upon the manner in which their marches have been arranged.

The usual instance of bad logistics in marching cited in textbooks is that of Gen. Hull in the campaign of 1812; but the report of Gen. A. J. Smith on the Red River expedition of 1864 contains nearly as fine an example. It shows that when Gen. Banks was advancing from Grand Ecore toward Shreveport on a single road at a time when he must have expected an attack, he divided his command by placing the wagon trains in the center, and not only that, but he also sent his heavier baggage with one division, in steamboats, up a narrow river on an exposed flank. Gen. Banks was defeated and driven back on the 8th of April at Sabine Cross Roads, and was only saved the next day by Gen. A. J. Smith, who having passed the wagon train, met and defeated the pursuing Confederates at Pleasant Hill. Gen. Banks then decided to retreat, in spite of Gen. Smith's remonstrance, "that Gen. T. K. Smith's command, then thirty miles above Nini on the transports in the river, would undoubtedly be captured and the transports lost if left to themselves." By sheer luck they escaped.

Had Gen. Banks studied Cæsar carefully he would not have made this error. That general, when advancing to the attack or near the enemy, always sent his baggage to the rear, and his precaution in one instance saved his army. He was marching through the country of the Belgae, and hearing that they were encamped about ten miles away on the Sambre, he proceeded to attack them. The night before some of the prisoners whom he had taken escaped, and joining the Belgae, told them that each legion was separated by its own baggage from the next legion behind it, as indeed it was on route marches, and that they might easily overwhelm the first legion before the others could come to its assistance. This plan was adopted; but Cæsar having brought six legions to the head of his column and sent the baggage to the rear under guard of two others, the poor Belgae, who waited until they saw the baggage train to make their onslaught, came to grief. When the Austrian general, Kray, was forced to retire from Ulm in the campaign of 1800 by passing around the right flank of Moreau's army, he sent his pack and train through Craleu to Nordlingen, while he marched his army over the Heidenheiner Nordlingen road, twelve miles nearer the enemy. In this manner he not only covered the march of his impedimenta, but also secured a clear path for his troops.

In former times, as an army penetrated into hostile territory, it either drew its supplies from its own base or lived entirely upon the resources of the country it entered. The first of these systems tied an army too closely to its line of magazines; the second caused too great a dispersion of the command, besides, it was not always practicable. One of Frederick the Great's generals calculated that the Prussian Army, in his day, was prevented from moving more than 100 miles from its magazines by the necessity of procuring assured subsistence. The German assumption is that a corps of 35,000 men and 10,000 horses, occupying forty-five square miles of moderately fertile and populous country, can find in that area subsistence for one day without difficulty. Now, on this basis, had the German effective army, as it existed in February, 1871, viz., 1,350,787 men and 263,735 horses, entered France and lived entirely and solely off the country (205,000 square miles) it could not have remained six months without starving.

The modern plan, introduced by Napoleon and practised by the Germans, is to seize all the provisions along the line of march and also to fill the magazines and depots by supplies drawn from the base. But whatever system be followed, the establishment of such intermediate depots (where provisions may be stored) between an army and its base of operations, is a necessity. No general was more careful in attending to this than Napoleon, and on his Russian campaign of 1812 he had six lines of magazines between Moscow and Berlin, and in Spain he had a continuous line from Bayonne to Madrid, some 230 miles long. It is estimated that to guard the various lines of communication between these depots and the army it takes about 1,000 men for every fifteen miles on each line.

That a commanding general may be able to make any definite plans against an enemy it is necessary that he should know something as to what that enemy is doing, or is about to do, and where he is. To find this out, as well as to conceal his own movements, the front and flanks of an army are covered by swarms of cavalry, the foremost being in touch with the enemy. These capture the enemy's scouts, intercept despatches, tap telegraph and telephone wires, open and search the mails and gain such intelligence as they can from the inhabitants of the country. Even if little direct information be given by a captured enemy, yet his uniform will tell the corps he belongs to.

The addresses on envelopes may show where certain troops are, and newspapers are only too apt to give valuable details of army movements. It was through the newspapers that the Prussians in 1870 first heard of the march of McMahon to the relief of Bajami. The notebooks, memoranda, etc., found in the clothing of the killed are all useful. Small scouting parties may also penetrate at night through the enemy's outposts or place themselves near his line of march to observe his strength. In this manner Col. Clark of Gen. Banks' staff remained all day within sight of Jackson's moving columns and counted their numbers.

Spies are the best means of obtaining an insight into what is going on in the midst of the enemy; but they are not always trustworthy, and they cannot know the object with which the movements they observe are executed.

A reconnaisance in force is only made by order of the commanding general, for the purpose of developing the enemy's strength and position preparatory to a battle. It should be carried out late in the day, so that night may put an end to the fighting, and the general may make such changes in his dispositions as the reports of the staff officers accompanying it may render necessary. But it is after the reports from all these various sources have been received that, says Gen. Von der Goltz, the most difficult part of all remains to be done, which is to decide upon the use that is to be made of this information. The general in chief ought to base his opinion with regard to the enemy upon the sum of all information and of all indications considered as a whole. But the power to do this is an innate gift which practice merely perfects.

The intelligence department of the French Army was so defective in their last war that two battalions of German infantry, a squadron of cavalry and a battery of artillery were able by rapid marching and maneuvering to hold the line of the Rhine for a distance of 106 miles and to cause two divisions to fall back from Mühlhäusen to Belfort in the belief that they were threatened by a whole army corps. The information concerning the seat of war in general, its topography, resources, the disposition, religion and habits of its inhabitants—in fact, the fullest knowledge of the enemy's country and people should have been collected and studied long before war is declared, and maps, plans of fortifications, towns and villages, etc., should all be ready to hand.

The German general staff numbers 200, of whom fifty are engaged in purely scientific branches, seventy-five are with army corps and divisions, and the remainder are busied in collecting and classifying intelligence concerning all countries, studying for that purpose everything from guide-books to financial budgets. It is not, however, only the compiling of statistics and making of maps which is the duty of the staff. Theirs is the whole range of logistics, of which we have had but a glimpse, and it was mainly owing to the careful training, constant study and indefatigable industry of the staff that such great results were attained by the German army in 1870-71, and that the chief of staff could definitely and truthfully report, eighteen months before the war, for which he was then submitting a plan, broke out: "Our mobilization is complete down to the most minute details. Six through railways are available for transport to the district between the Rhine and the Moselle. Time-tables, indicating the day and hour for the departure and arrival of every train, are prepared."

Not only does the German staff gain knowledge from past history, but it learns how to apply that knowledge so well to present-day circumstances that it beat France with Napoleon's own weapon of warfare—momentum. In view of this faculty of adaptation, you will find it difficult to join with Sir Edward Hamley in decrying the study of ancient military history where you find, in Josephus, the account of a military organization at the time of King David strongly resembling in a general outline the famous Landwehr system of the Prussians—a reserve of all men capable of bearing arms, excepting certain classes, which numbered over 1,300,000 men, and a standing army of 288,000 men, of whom 24,000 served with the colors each month and then went on furlough.

"A good staff," says Jomini, "is more than all indispensable to the constitution of an army. It has the advantage of being more durable than the genius of any single man and constitutes for the army the best of safeguards." But in proportion to the safety and advantage gained by having a competent staff are the danger and disadvantages incurred by having a poor one. Compare the boastful utterance of Marshal Le Boeuf to Louis Napoleon, "Everything is ready, sir, down to the last button," with the actual state of unpreparedness and disorganization that existed in the French army, and you can readily see the difference between such a chief of staff and one like Von Moltke, whose every combination was carried out as he had planned. When crossing the Danube before the battle of Wagram, Napoleon's chief of staff assigned two of the pontoon bridges to the wrong *corps d'armée*, and as these two corps passed each other in the night, had it not been for the good sense of the men and their officers, a dreadful scene of confusion might have been the result. The life of a conscientious staff officer is far from being one of indolent ease. In peace he is studying and attending to the routine duties of his particular branch; in war he is everywhere, now making a reconnaissance in front of the advanced outposts, where the bullets of the enemy spatter around him, and again, far in the rear, directing the baggage trains over an ugly piece of road. When night comes the line officer can sleep, but he of the staff must be up, receiving and making reports, writing out orders or carrying despatches to distant parts of the command. Nor has he often been mentioned in history. Of the millions who have heard or read of Washington and Napoleon, how many are aware that Maj.-Gen. Hamilton and Marshal Berthier were their respective chiefs of staff? Blücher, Moreau and Ney are familiar names to thousands who never heard of Scharnhorst, Dessoles and Jomini.

Field Marshal Von Moltke is the one chief of staff whose name is to-day, and will be hereafter, more often mentioned in connection with the last great war which he conducted than that of his imperial commander-in-chief; and this fact marks the epoch in military history when the brain that plans began to be considered at least the equal of the hand that strikes.

Numerous as already were the different departments of logistics when Jomini wrote his "Art of War," the fertility of modern invention and the demands of modern civilization have added yet more to them. The electric nerve fibers of an army nowadays connect the commanding general in one direction with his advanced outposts, in the other with his base of supplies, besides linking together the different portions of his command. The wires of the German field telegraph service alone at the end of the war had reached a length of nearly 6,730 miles. Nor is this the only military use to which electricity will be put. In the next great war both fortifications and the exposed portions of intrenchments will doubtless be provided with electric searchlights.

The introduction of high explosives and smokeless powder have rendered the study of chemistry most requisite, while the balloon, which, when first used by Marshal Jonadoin at the battle of Fleurus in 1794, was considered a failure, has now become a recognized necessity, involving the acquirement of the art of aeronautics.

At the commencement of the Franco-German War 251 wagons were employed by the Field Post Office Department in carrying the mail, which was then restricted to letters. On October 15th, 1870, this restriction was removed, and within fifty-five days 1,219,533 packages were delivered by it, this taking 560 railway cars and many hundred vehicles.

As though the train of war were not yet long enough to be fashionable, the French have added to it thirty bakery wagons for each 10,000 men. Nor do these carry any portion of the flour or bread; ten are the ovens, ten are for utensils, and ten for the bakery detachment. The size of the standing armies of Europe has, however, affected logistics in a more important manner than by merely adding to the departments and increasing the amount of transportation, for as they can only be kept up at an expense which strains all the resources of the State, the practice of the most rigid economy and the closest attention to the minute business details of each department are imperatively necessary. In fact, war, formerly the occupation of princes and conducted with all the extravagance and pomp befitting such exalted personages, has now become an art, depending for its successful accomplishment as much upon the shrewd and methodical habits of the merchant, the ingenuity of the inventor and the practical ability of the mechanic as upon the courage and devotedness of the soldiery.

The Dawn of Architecture

First Steps in the Evolution of the Human Dwelling

By John L. Cowan

No doubt when primitive man first learned to walk erect, and in other ways became differentiated from the ancestral beast, his earliest homes were natural caves and shelters in the rocks. Then, when the increase in the numbers of the human family made it necessary for its members to scatter into regions where ready-made homes were not found, it was inevitable that the first artificial dwelling places should be built after the model supplied by nature. Accordingly, the first efforts in the direction of home-building doubtless consisted in the enlargement of existing cavities in the cliffs; the next were directed to the excavation of wholly artificial caves—mere holes in the ground, or in soft rock-strata, into which the men of the Paleolithic Age were able to dig and burrow with the crude tools at their command. This was really the dawn of architecture. True, many beasts did almost as well; and numberless birds and insects did much better; but these worked only with the organs that nature gave them, while the human excavators of the first cave-like homes in yielding rock brought to their assistance tools made of harder rock. The use of tools proves the beginning of invention, and that indicates that reason had begun to supplant instinct as man's guide.

This is only one of the many problems connected with the early history of culture that seem in a fair way to elucidation through the investigations of Dr. Edgar L. Hewitt, Dr. J. Walter Fewkes, and other American archæologists in what is known as the Pueblo region of New Mexico, Arizona, Utah, and Colorado. Just as the fossils found in rock-strata make it possible for scientists to reconstruct with more or less completeness and accuracy the fauna and flora of the geological epochs to which they belonged, so does the study of prehistoric ruins, their contents and surroundings, make it possible, within certain limits, to reconstruct primitive society. The isolated position of the Pueblo region left its primitive inhabitants free to work out their own salvation, with little interference from the world at large; and the same condition, together with the aridity of the climate, has prevented the disintegration and decay of monuments of ages long past, so that here is presented a remarkable opportunity to investigate the origin and development of culture.

The theory of "equivalent development" is now universally accepted. In this expressive phrase is summed the convenient hypothesis that even the most widely separated and totally unrelated peoples probably passed through the same stages of culture; and that in the same stages they developed the same arts and industries, lived in the same kind of dwellings, made use of the same description of tools, weapons and utensils, and experienced much the same moral, intellectual and religious aspirations—subject, of course, to such variations as different climatic and physical environment necessitated. This is the reason why the myths, traditions and folk lore tales of antipodal peoples sometimes exhibit such startling analogies. These analogies used to be considered as giving evidence of the common origin of mankind; and the strange parallels in the beliefs, superstitions

A Stone Idol of the Cliff Dwellers in Pajarito Park.

and mythologies of widely separated peoples were used as arguments in support of the belief in a common ancestry. These curious coincidences and analogies are now perceived to cast no light upon any matter relating to the origin of man or the diffusion of races; and are accepted merely as confirmatory of the reasonable theory that under identical conditions men are likely to think the same thoughts, and to express them in much the same manner. So it happens that the Hottentot and the Papuan cherish the same myths and fables that the old Aryans of thousands of years ago related to their children, and that form the basis of the Mother Goose rhymes and nursery tales and cradle songs of the cultured peoples of Europe and America. So it happens, also, that when we study the origin and development of any art or industry among the primitive peoples of the American Southwest (or anywhere else for that matter) we are learning the precise methods by which our ancestors developed similar arts and industries in the kitchen middens and cave dwellings of the Stone Age of Europe.

In the development of architecture, almost everything depended upon the nature of the country. The tribes that were forced to the level plains, at an early stage in their career, by the pressure of a stronger race; or that traveled from place to place in pursuit of migratory game animals, never became builders, in the proper acceptation of the term. As soon as they had learned how to construct rude but portable tepees of bark or the skins of animals, they had attained the utmost limit of development consistent with their manner of life. Those that confined their place of residence to a well defined region, but yet moved with frequency, did a little better. Fairly typical of these are the Navajo Indians, building their homes (called hogans) of the trunks and limbs of trees; and covering this rude skeleton-dwelling with earth. This, we suspect, is nothing more than an imitation of the ancestral cave. True, it is not a very good imitation; but it follows the outlines and reproduces the conditions of a cave as closely as the means of the tribesmen would permit, after their migration into a country in which natural caves did not exist, and in which opportunities were wanting for the easy excavation of artificial caves. Intellectually the Navajo is quite capable of the construction of much better homes than the members of that important tribe have ever occupied. Probably the evolution of the cave-like hogan into a higher type of dwelling was arrested by the custom that has existed from immemorial antiquity of abandoning a dwelling whenever a death occurs in it. With the term of occupancy rendered so uncertain, the incentive to architectural improvement was wanting.

Permanence of residence, it is plain, is the first essential to architectural progress. Among primitive peoples, the only great builders were agricultural races. The shepherds and the hunters, from the very nature of their occupations, were more or less nomadic, condemned to find shelter from the elements in temporary and insubstantial structures. Only the farmers were in position to feel justified in expending the time, thought and labor involved in the construction of homes that might last for generations or for centuries. In regions where the construction of irrigation works was necessary to successful agriculture, an added guarantee of stability and permanence was given, with consequent greater incentives to architectural elaboration. Hence, the great builders of past ages have been agricultural races, living in arid or semi-arid climes, as on the plains of Babylonia, in Asia Minor, the Nile valley, Peru or Mexico. The architectural monuments remaining in the American Southwest are in no way worthy of comparison with

Near View of Pu-ye Cliff Dwellings. The Rooms Were Hollowed Out by Hand. The Small Holes Contained the Ends of Beams Supporting Balconies.

Prehistoric Stairway at Pu-ye Leading From the Dwellings on the Face of the Cliff to the Mesa Ruins Above.

THE ABODE OF PREHISTORIC MAN.

those in any of these regions; but the fact that they remain in an unbroken series, from the very lowest to a relatively high stage of development, makes them infinitely more instructive than the far more imposing ruins found elsewhere.

Possibly the most important work in archæological research that has yet been undertaken in the United States is that of a newly established Museum of New Mexico, under the direction of Dr. Edgar L. Hewett. Excavation so far has been confined mainly to the Pu-ye ruins, on the Jemez plateau—a cliff 5,750 feet long, honeycombed with abandoned human habitations, in some places three tiers high. Across the canyon is another cliff, the Shu-fi-ne, almost as noteworthy for its ruins, and in the same wonderful region of volcanic cliffs there are at least one hundred miles of similar prehistoric dwellings—chambers excavated with patient toil in the yielding rock. Important excavations have also been made in the Reto de Los Frijoles, in the same region. These caveate homes, however, are only a fraction of the homes of men that once existed in this region. Along the bases of the cliffs were thousands of other dwellings, many now almost obliterated by the wear and tear of the elements, and others buried by the rock debris falling from above. Then on the summit of the Pu-ye (and the same may be said of other mesas) are the ruins of a great, three-story communal house that must have contained at least 2,000 rooms.

Portion of the Community Dwelling Ruin at Pu-ye Above the Cave Dwellings. About Eight Hundred Rooms Have been Excavated and About Three Hundred More Remain to be Uncovered.

The excavation and exploration of the Pu-ye and neighboring ruins is important for the reason that it has been totally uninhabited during historic times, so that the culture there attained was strictly aboriginal, with no trace of European influence; and the further reason that neither amateur scientists nor vandal tourists have greatly disturbed it. There is, therefore, good reason for the anticipation that the researches now being conducted by Dr. Hewett will result in highly important contributions, not only to American archæology, but to the sum total of human knowledge concerning the origin and development of culture.

There is no evidence that true troglodytes ever dwelt in the Southwest; but the first step in home-building—namely, the enlargement and improvement of natural cavities in the rocks—is fully illustrated, not only in the Pu-ye, but in many others of the cliffs. Something like a thousand square miles of territory was covered to perhaps 2,000 feet in thickness with volcanic tufa. Through this, intermittent torrents on their way to the Rio Grande cut deep canyons, with towering, precipitous walls, refractory enough to resist the elements, but soft enough to be worked by means of tools of obsidian. In the tufa walls, as the centuries passed, numerous cavities were shaped by wind erosion. Many of these shallow caves were enlarged and improved to adapt them to human habitation, excavation being the only industrial process employed. Structurally, these are the most primitive human abodes found in the Southwest, or perhaps in America.

The next step toward the beginning of true architecture was the excavation of artificial caves for homes, with natural front walls, entrance being effected by means of narrow openings. Of these caveate dwellings there are many thousands in the Jemez plateau. Some of these consist of but a single chamber, while others have several. They are usually, but not always, located in positions easily susceptible of defense, with floors somewhat below the level of the threshold, with crude fireplaces, and often with smoke vents. The rooms are well shaped, floors and walls plastered, and various decorative processes employed. Dwellings of this kind display a vast advance in constructive ability over the most primitive type.

But the father of all architects was he who first discovered that he could build a wall by the simple process of piling stone upon stone. That discovery marked the introduction of a new idea into the sluggish human gray matter—and new ideas are the rungs in the ladder of progress, by means of which mankind has climbed, painfully and with infinite labor, from the deep pit of barbarism and bestiality to the exalted pinnacle of civilization and enlightenment now attained. The introduction of mortar, the beginning of carpentry, the invention of the column, the discovery of the arch, and a thousand other improvements, followed inevitably, with the lapse of ages; but the building of the first wall by the piling of stone upon stone was an epochal invention of more moment than all later devices put together.

No doubt Necessity, the fecund Mother of Invention, supplied the inspiration of the first wall builder. In numerous places throughout the country of the Cliff Dwellers may be seen ancient caveate dwellings from which the front wall has fallen away. No doubt the slow crumbling of the cliffs brought the same result to pass when these strange abodes were occupied: and many of the dwellings that have front walls of masonry have the appearance of once having possessed natural walls of living rock which had been destroyed by the gradual disintegration of the cliff. When a catastrophe of that kind occurred, the householder found himself under the necessity of moving out and digging a new hole in the rock, or else making repairs. It may be that once upon a time an accident of this nature happened in midwinter, when manual labor upon the face of a frost-bitten cliff was physically impossible; and that the first wall-builder tried this new expedient in order to escape the disagreeable alternative of accepting the grudging hospitality of stingy relatives or gossiping neighbors for the provision of shelter from the New Mexican storms for the loving sharer of his humble cave and an interesting family of little cliff dwellers.

Inevitably the success of the first wall builder begot imitation, improvement, and the application of the idea in different ways. Perhaps someone had excavated a large living-room for the accommodation of a large family of daughters. As these grew to womanhood and were wooed and won by sturdy young men of the cliffs, it is possible that one of them made a mesalliance, and that her father found it more convenient to subdivide the commodious front parlor by building a stone partition wall than to help a lazy or improvident son-in-law excavate a new dwelling. Of course this supposition is purely gratuitous; but chambers subdivided in this manner are occasionally found; and it is probable that the same domestic problems came up for solution in those days that sometimes arise in this advanced age.

Again, it is possible that some love-lorn swain knew of a tempting and convenient location for a cosy home for two on a rocky ledge overhung by a beetling cliff. With the roof and rear wall thus ready-made, if he was anxious to economize muscular energy, it may have occurred to him that it would be easier for him to build two side walls and a front wall than to dig out a whole dwelling.

Then came the building of three-walled dwellings, with artificial roofs, anchored at the rear to the cliff. An astonishing series of these have been partially excavated at the base of Pu-ye, and doubtless many more are still buried beneath the talus heaps. These "pueblo-like cliff dwellings" exhibit every feature of independent pueblo architecture. Masonry, plastering and carpentry are involved in their construction. It was no doubt by these that the terraced form of construction which still persists in the communal dwellings of the modern Pueblo Indians was suggested. The primitive type consisted of one-story buildings; but their situation on the sloping talus at the foot of the cliff made terracing necessary, and probably gave the structures the appearance of consisting of several stories.

As soon as the stone wall had been perfected, the cliff dwellers were ready to leave the shelter and support of the ancestral cliff; but it is probable that it was centuries before they found this out. In some regions great and substantial masonry buildings were constructed on ledges overhung by cliffs—as, for example, the Cliff Palace and Spruce Tree House, in the Mesa Verde, of Colorado; and Montezuma Castle, on Beaver Creek, Arizona; and others, as at Pu-ye, were built up to a height of two and three stories upon inconvenient rubbish heaps; but all were anchored in some manner to the cliff, for no other conceivable reason than the wholly suppositious one that the builders did not have enough sense to know that their walls would stand alone. The bold Sir Christopher Wren of the Stone Age who first hazarded the construction of a four-walled house, without a cliff to lean against, was another epoch-maker who missed deserved immortality. It requires no great stretch of the imagination to conceive of the universal hoot of scorn and derision that greeted his proposal to cut loose from the cliff that had been a sure shelter and support for unnumbered generations, and to build in the open. No doubt the wiseacres gave his proposition the same kind of a reception that was accorded the "cranks" and dreamers who invented the locomotive, the steamboat, the telegraph, the telephone and the skyscraper, and numberless and confident must

have been the predictions that the first strong wind that swept across the mesa would scatter the frail walls in irrecoverable fragments all over the landscape. Nevertheless, the "crank" defied precedent and prophecy; and, to the amazement of everyone, his house defied the storm.

No doubt the practical demonstration of the fact that a four-walled house of stone would stand, even without a cliff to lean against, was followed by a town lot craze upon the mesas that would make even present-day boomers of suburban property sit up and take notice. For, when these prehistoric Americans forsook the cliffs, they sought the mesas, rather than the valleys or canyons, because the mesas afforded building sites that were as easily susceptible of defense as the eagle eyries in the beetling cliffs themselves. The same desire for a location that would make defense against predatory nomads an easy matter commonly guided the Pueblo Indians in the establishment of their towns. Gibraltar itself is hardly more defensible than the town sites of Acoma, Walpi, and Orabi; and many lofty mesas in the Southwest have crumbling ruins upon their summits which prove that forgotten peoples once dwelt securely upon their heights.

Having moved from the cliffs to the mesas, the aborigines soon attained the climax of their architectural and industrial development. The oldest type of masonry structures on the mesas consists of one-story buildings, containing one, two or three apartments, evidently intended for the accommodation of a single family. But the Mesa-dwellers (for, strictly speaking, they had ceased to be cliff dwellers,) like the modern Pueblo Indians, were extremely gregarious. It is thought by some investigators that the law of growth that now prevails in Pueblo Indian communities is the same that governed the development of the communal towns of the Cliff- and Mesa-dwellers. A new family is always annexed to the maternal clan; and, wherever possible, the house of a newly married daughter is built up against the home of her mother. This possibly accounts for the irregular and straggling buildings found in many places; but when circumstances made it necessary for an entire community to seek a new location (owing to the mischances of war, the ravages of epidemic diseases, or the necessity of finding a better water supply or additional lands for agriculture), an opportunity was afforded for the construction of imposing and symmetrical structures that, even in their present ruined condition, are amazing exemplifications of what skill and industry are capable of accomplishing, even with the most inadequate of tools. Some of the prehistoric town builders used flag stones, just as the Hopi Indians do to-day; but others laboriously dressed blocks of tufaceous rock, for the construction of great terraced, pyramidal buildings, sometimes four or five stories in height, and containing thousands of apartments. There is not an apartment house in Chicago or New York to-day that contains as many rooms or accommodates as many people as did the great pueblo on the summit of Pu-ye.

This Pu-ye cliff is interesting and important because here, within a radius of half a mile from the ruined pueblo on its summit, may be seen illustrated every step in the evolution of architecture; the wind-worn cave, the cave excavated by human toil with natural front wall, the caveate lodge with artificial front wall, the building of three stone walls hugging the cliff, the isolated four-walled dwelling for a single family, and the great terraced communal pueblo for the housing of a population of thousands. Then there is every conceivable gradation from one type to another, giving an illustration of the growth of the most important of the industrial arts that can hardly be matched anywhere in the world outside of the Pueblo region of the Southwest. It is not improbable that as the excavation of the Pu-ye and neighboring ruins progresses, and as the prehistoric relics there found are assembled and classified in the great museum that is being built up at Santa Fe, the evolution of other arts and industries that form the very basis and foundation of organized society may be illustrated as graphically.

The Ylang Ylang Perfume Plant

The plant known as ylang-ylang, from which the well-known perfume is extracted, grows principally in Reunion Island. It was first cultivated as an ornamental plant, but commenced to be distilled as a perfume in 1880. Since that time the colonists have been so actively engaged in this field that the result was a veritable overproduction after 1906. In 1909 there was exported 1.4 tons of the essential oil which forms the base of the perfume. At present other colonies are taking up the matter, including Madagascar and the Comores. The trees grow as high as 40 to 60 feet on the average. Some care must be taken in planting the trees, as they suffer much from strong winds and they cannot be grown in Reunion at altitudes above 1,700 feet. This region, it should be remarked, lies at about 21 deg. south latitude. In order to produce a great number of flowers the trees must be grown in rich soil which can be watered by irrigation if need be. In the planting, the ground is covered with a layer of powdered charcoal or with sawdust or straw. The plants sprout in 30 to 50 days. When they appear, they are sheltered like the Hyères palm by a protecting covering of dry leaves. The plants are often attacked by snails. After the plants reach a certain size they are put in pots made of bamboo, for a further growth. The flower from the trees is at first white but then changes to a yellow, after which it is plucked. After two years of age, the tree or bush commences to bear flowers, and a four-year-old plant will produce as much as 10 pounds of them. To obtain the essence, the flowers are distilled when fresh in an ordinary alembic of 40-gallon size, and the yield is from 1½ to 2½ per cent of the weight of the flowers. Should a finer quality of essence be desired, the distilling is done more quickly, but in this case the yield is only 1 per cent. In this latter case 30 pounds of flowers are put into the alembic and the distilling operation takes about nine hours, resulting in 0.3 pound of essence.

Correspondence

Experiments With Aerial Propellers

To the Editor of The Scientific American Supplement:

At the present moment the prevalent tendency in the aeronautical world can be observed to be divided into two paths, the concentration of efforts being devoted to improvement of the aeroplane, and to increasing the efficiency of the propeller. From exhaustive observation and experiment the writer concludes that as regards securing increased thrusts per horse-power, the present type of wooden blades appears to hold out a promise of improvement, but on the other hand an abnormal increase of thrust is decidedly limited. In fact, although efficiency can certainly be augmented, *increase of diameter* is unquestionably the solution of yielding greater thrusts per horse-power than those given by experimentalists of known repute. At the same moment, when thus securing reliable genuine data, it will be learned that the present screw universally adopted as tractor or propeller leaves little to be desired as regards efficiency statically, or in flight on aerodynamical machines, yet

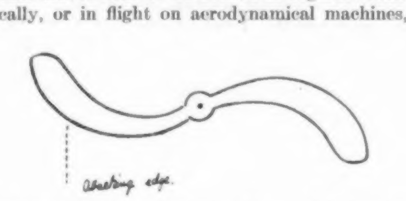


Diagram Showing Improved Form of Propeller.

this should prove no barrier to the fact that there is still open judgment in the belief that a certain screw will give greater thrusts per horse-power, provided the *shape* be improved, resulting in scientifically attacking the air in rotation, and consequently augmenting the thrust.

Taking for a basis the present knowledge at hand from an unbiased standpoint, and ignoring theoretical mathematics for actual demonstration, we find the prevalent type universally employed is that of the Chauviere form, built up of wooden planks to the curve and the design so well known. The attacking edge is perfectly straight, while the receding edge is convex or rounded, the tips rounded with an approved section of concavo-convex form, the general design throughout being of true helicoidal curvature. Since virtually every known aeroplane is fitted with these or copies of the same, with but few exceptions, we will for the time accept this as the acknowledged best, and as a groundwork to improve upon. By comparing this configuration however with the premier screws extant—those shown by nature as exemplified in the bird, the bat, and the insect—and particularly those driven at exceedingly high velocities, similar to those of man, we find that here the attacking edge is admittedly of convex design, while in some examples, as the swift humming-bird, and certain insects, the receding edge is more or less of marked concavity, while those of man are conspicuously lacking in this respect.

Clearly, then, it is safe to assert that shape is a by no means negligible quality in seeking our ideal screw; but, on the other hand, there are much more important considerations in the design and the construction needing embodiment. Pitch, diameter, lightness, area, and smoothness of contour form the chief factors in superiority. For that reason, therefore, one should accept with reserved judgment the claims of some constructors, basing, for example, a thrust of 25 pounds per horse-power with a 6-foot diameter screw, the power at disposal being equivalent to only 1 horse-power, giving, at 100 horse-power, a theoretical thrust of 2,500 pounds. As such, this is grossly misleading, inasmuch that, however effective the screw, the *diameter* or "disk area" swept out in rotation and volume of air displaced is inadequate, the thrust per horse-power in practice yielding a bare 5 pounds per horse-power, or only 500 pounds with an expenditure of 100 horse-power. To attain a proportional increase of 25 pounds per horse-power, the area and diameter should be greatly increased, while the revolutions *decrease* in direct ratio to the area or to the number of blades in conjunction with the diameter employed. To what extent these desiderata may be desired, the following tabulated results subjoined, which are substantially authentic for practical illustration and basis, will reveal on comparison:

Name	No. of Screws.	Diam.	Total thrust in lbs.	Total H.P.	Lbs. per H.P.
Giffard	1 (two blades)	8	165	6	27.5
Dalhstrom and Lohman	1 (two blades)	8½	55	1½	36.7
Renard	1 (two blades)	23	432	9	48
Moy	2 (two blades)	12	120	3	40
Maxim	2 (two blades)	17′ 10″	2,000	363	5.3
Kress	2 (two flexibles)	12	82	1-3rd.	27.3
Santos Dumont	2 (two blades)	20	400	28	17.5
Santos Dumont	1 (two blades)	20	198	9	22
Santos Dumont	1 (two blades)	6½	332	50	6.6
Léger	2 (two blades)	20	240	6	40
Bréquet	8 (32 blades in all)	26½	1,190	40	29.2
Cornu	2 (two blades)	19.6	853	24	35
Rankin Kennedy	2	5	72	3	24
Pickering	1 (two blades)	12	48	1	48
Pickering	1 (two blades)	20	430	20	21.5
Chauviere	1 (two blades)	8½	375	50	7.4
Latham	1 (two baldes)	6′ 10″	275	50	5.5
S. H. Hollands	1 (two blades)	6½	26.5	1	26.5
P. Y. Alexander and Walker	1	30	1,250	30	25
G. L. Davidson	2 (each 32 blades)	27′ 8″	6,720	100	67.2

This list has been chosen from more exhaustive figures in possession of the writer purely for illustrative examples, those remaining producing precisely similar results. By comparing the thrusts, areas, diameters, and horse-power, particularly those of Maxim, Brequet, Pickering, Latham, and Davidson, it will be seen that the ratio of lift or thrust varies in proportion one with another in the same unalterable law. For example, take S. H. Holland's tests with only 1 horse-power, with a small 6½-foot diameter screw, to one of similar size of Santos-Dumont, but with 50 horse-power. The first yields the respectable sum of 26½ pounds, but only 6.6 pounds in the case of the latter, with increased power. In comparing the large diameters, the difference is still more striking. Maxim's 2,000 pounds thrust, with twin screws 17 feet 10 inches in diameter, each at the expenditure of 363 horse-power, fades into insignificance when comparing the great lift of Davidson's 6,720 pounds, with larger size propellers and increased area, with only 100 horse-power, or at the ratio of 67.2 pounds, against only 5.3 pounds per horse-power of Maxim's! Such, then, are the actual facts and figures well worth pondering. In the light of these results there can be no doubt or question that by improving the shape and increasing the diameter and the area, the thrust is proportionately augmented, while it is certain that for large diameters higher efficiency is secured by increasing the number of blades.

Pimlico, London, England. Edgar E. Wilson.

Snails in Ceylon

Although some damage is done to plants or trees by snails in our ordinary climates, especially in periods of damp weather, this is comparatively of little importance when we find what occurs in other zones. One very unusual case was noted in Ceylon not long since where a veritable army of big snails invaded the region to the north of Bernwala and overran villages and fields in quantities so large that the ground was literally covered with them. The plants did not suffer at once, as the snails have a great liking for all kinds of refuse, but they soon began to attack the young ones, eating leaves, bark, flowers and fruit. This variety of snail is known as a *chatina fulica* and it has an unusual length, some 4 or 5 inches. It is very prolific, so that it spreads rapidly. Its natural enemy is the common turtle and also a variety of ant which eats large quantities of the eggs. The snail is very hard to exterminate and in these countries the only method seems to be to surround the fields with ditches which prevent them from crossing. Trees are protected by putting cocoa bark rings saturated with tar or pitch around the base of the trunk.

Sympathetic Ink (black).—Write with a solution of one of the following salts: (1) sugar of lead or nitrate of bismuth; (2) green vitriol (very dilute); (3) chloride of mercury. The writing is brought out by passing over it with a solution, for 1, of sulphide of hydrogen in water, for 2, of gall-nut decoction; for 3, of tin salt.

Detecting Adulteration of Oils*

New Method Discovered for Determining Oil Adulteration by Mineral or Resin Oil

By Alexander E. Outerbridge, Jr.

WHEN examined by reflected light, hydrocarbon oils (improperly named "mineral" oils), whether crude or partially refined, show a peculiar greenish tinge commonly called "bloom." When examined by transmitted light the bloom disappears and the true color of the oil is seen. This color ranges from dark red or mahogany tint through various shades of orange and yellow up to "water white," according to the degree of refinement. Resin oil possesses the same peculiar characteristics, except that the color of the bloom is pure blue. Its chemical composition is so nearly like that of a hydrocarbon oil that these resemblances appear to me to be more than accidental coincidences and suggest the possibility of a common origin between so-called mineral oil and resin oil. This speculation, however, is not germane to our topic, which has to do strictly with a new practical application of that property commonly called bloom to the instantaneous detection of adulteration of vegetable or animal oils with hydrocarbon oils.

FLUORESCENCE OF CERTAIN OILS.

Doubtless everyone has noticed the bloom in mineral oils and wondered perhaps as to the cause of this singular greenish appearance, which is especially noticeable in crude oil and in heavy lubricating oils. Bloom is merely a popular name for a remarkable property possessed by a number of substances, the scientific name for which is "fluorescence." In simple non-technical words, fluorescence is a property inherent in some substances of becoming self-luminous while exposed to certain rays of light known as "ultra-violet" or "actinic" rays. These rays are always found in sunlight and in some forms of electric light.

In the course of my investigations I found that the greenish bloom of fluorescence of mineral oil and the blue bloom of resin oil noticeable in daylight can be enormously intensified or magnified, perhaps a thousand fold, so that, if a single drop of mineral oil is placed in a vessel containing a hundred or even a thousand drops of pure linseed oil, or any other non-fluorescent oil, its presence may be instantly detected by the greenish fluorescence which it imparts to the whole of the oil. The same is true of resin oil, which makes blue fluorescence. The utilization of this observation for practical purposes of detecting adulterations is the gist of this paper.

By preparing standard samples of any non-fluorescent oil containing one-tenth, one, two, three per cent, and upward, of mineral or resin oil, in clear glass test tubes placed in a suitable frame against a dark background, each showing readily and unmistakably the increasing proportions of the adulterant under a light giving ultra-violet rays, a "fluorescent scale" has been established, somewhat similar to the well-known carbon color scale used in steel foundry laboratories for quickly determining, by color comparison, the proportion of carbon in an acid solution of steel.

I am prepared to make unhesitatingly the broad assertion without fear of contradiction that there is no method known by which the presence of either mineral or resin oil in any non-fluorescent oil in small or large amount can be so disguised as to be undetectable instantly by this method, and this certainly is an interesting and important fact of considerable practical value to consumers of costly oils.

TEST APPLICABLE TO DE-BLOOMED OILS.

Methods of chemical treatment of mineral oil have been discovered to "de-bloom" mineral oil so that it can be used with impunity, so far as the bloom is concerned, as an adulterant for expensive vegetable and animal oils, and I learned that there is a very large trade in de-bloomed oils for this purpose. Samples of de-bloomed oils of different grades and colors were obtained. They are free from bloom in bright sunlight or ordinary diffused daylight, or in the light from an ordinary electric arc, but when subjected to the kind of light which I shall presently describe *they all became highly fluorescent*, and even the proportion of adulteration with de-bloomed mineral oil in any specimen of non-fluorescent oil mixed with such de-bloomed mineral oil may be stated. I anticipate that this positive statement now made for the first time will cause some consternation among makers of de-bloomed mineral oil.

If both mineral oil and resin oil be used in combination as adulterants, it becomes more difficult to make quantitative determinations instantly by the fluorescent method; hence the qualification implied in the word often. But "practice makes perfect" in many operations, and this is no exception to the rule.

HOW FLUORESCENCE IS OBTAINED.

It is the *ordinary inclosed arc*, so commonly used in industrial works by reason of its relative economy, that happens to give out rays of the exact wave lengths needed to enormously increase the fluorescence of these oils. If the plain glass cover of this light fits properly, so that air does not enter as rapidly as it is consumed, the arc burns in a partial vacuum or, at least, the air is rarified and, under these normal conditions, this light shows continuously, after burning a minute, a faint rosy light in addition to the powerful white light. If now a vessel containing any mineral oil, crude or refined, or any resin oil, be placed in the path of these rays the most intense fluorescence appears, even in daylight, greenish in the case of mineral oil, blue in the case of resin oil, thin films glowing in the same manner. So strong is this fluorescence that I have even detected 1 cubic centimeter of crude mineral oil in 999 cubic centimeters of non-fluorescent oil.

I have examined a large number of vegetable oils, such as cotton-seed oil, corn oil, China bean oil, China wood oil, etc., and have not found a trace of fluorescence in any of them. It is stated in some text-books that "oleic acid," which is found in lard oil, is fluorescent. On examination I find that pure white strained lard oil is entirely free from fluorescence under the ultra-violet ray, but all of the samples so-called No. 1 or No. 2 lard oil (sold for use in machine shops) examined possess some fluorescence, and this may prove to be a novel means of rapidly determining the proportion of oleic acid in lard oil, though I only suggest it tentatively, not having studied the matter carefully from this point of view. The slight fluorescence of ordinary lard oil is different in appearance from that of mineral oil or resin oil, and does not materially interfere with the application of the fluorescent test for its adulteration with mineral or resin oil.

SIMPLE SCHEME OF TESTING.

In daily practice I have found it convenient to put the standards in narrow tubular oil-test bottles holding about 50 cubic centimeters each; these are corked, labeled and placed side by side in small wooden racks (like test-tube holders) on a shelf in proximity to an inclosed arc light, beginning with pure oil at the left-hand side. Then a similar sample containing 0.1 per cent of mineral or resin oil, as the case may be, then 1 per cent, and so on, increasing by single percentages up to 10 per cent. It is advisable to prepare several different series of standards with fluorescent oils of different grades. Crude mineral or resin oils are much darker in color than refined oils, and the color by transmitted light is a guide to the kind of oil that has been used for adulteration and is consequently an indication of the proper standard series to be used for comparison in making a quantitative fluorescent analysis.

It is not necessary to prepare standards for each kind of vegetable or animal oil; thus, the standard series prepared with linseed oil serves for examination of cotton-seed oil, corn oil, China wood oil, China bean oil or any other non-fluorescent vegetable oil. It is necessary, however, to prepare special standards with lard oil for testing adulterated lard oils.

The compounding of core oils has become a large business and nearly all samples that have come to my notice contain mineral or resin oil or both. Neither of these oils impart any valuable properties to core oils, but are used simply to dilute more costly oils; and, in point of fact, they are positively deleterious, being of a non-drying nature, impairing the good oil binder and requiring more fuel and a longer time for baking the cores in the ovens.

I have found that "Soya" oil expressed from beans grown in enormous quantities in China and elsewhere is an excellent substitute for linseed oil for making cores if used in its natural state, without having been compounded or adulterated by core-oil makers. It costs about 60 cents per gallon for finer grades. The very best substitute for linseed oil as a binder for oil cores that I have discovered is crude whale oil, costing about the same as Soya oil, the only objection to its use being an unpleasant fishy smell which escapes from the core ovens during the baking of the cores. It makes a superior binder. Cotton-seed oil is used for the same purpose, but so much larger proportion of oil to sand is required that there is little economy in its use as compared with the other vegetable oils.

A simple and practical test of the value of core oils is to make a dozen companion test cores 1 x 1 x 15 inches from batches of pure linseed oil and sharp sand, and also from the same proportions of any other oil and sharp sand. These are placed side by side on an iron plate and baked under precisely the same heat conditions. When cold they are broken on a transverse testing machine with support 12 inches apart. The relation between the average strength of the two sets of test cores is a measure of the binding qualities of the oils.

* *The Iron Age.*

A New Ionium Collector.

ELECTRIC collectors or "sounds" are employed, in conjunction with electrometers, in measuring the electric potential at definite points in the atmosphere. The most convenient of these collectors are radio-collectors, consisting of small metal plates covered with radio-active substances which exert a powerful ionizing effect on the surrounding air. The Alpha particles emitted by the radio-active coating divide many air molecules into positive and negative ions. If, for example, the potential of the collector is lower than that of the surrounding air, the collector repels the negative and attracts the positive ions. The positive charge thus communicated to the collector raises its potential, and that of the electrometer connected with it, to equality with the potential of the air in the immediate vicinity. The reading of the electrometer then gives the value of the potential at the point in the atmosphere which is occupied by the collector (Fig. 1).

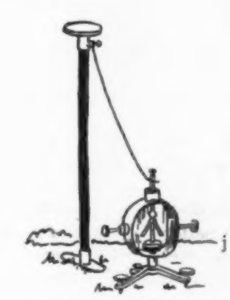


Fig. 1.—Radio-collector and Electrometer.

The radio-collectors which are most commonly used are coated with polonium, or radium *F*, by electrolysis. These collectors have the disadvantage that polonium is comparatively short-lived, its "half period" being only 143 days. Hence the quantity of polonium present and the activity of the instrument are reduced to half their initial values in 143 days, to one quarter in 286 days, one eighth in 429 days, and so on. In short, the collector rapidly wears out, unless the coating of polonium is frequently renewed, and this is an expensive process, owing to the high price of polonium.

At the suggestion of Elster and Geitel, the German Antarctic Expedition has been supplied with collectors coated with ionium, the long-lived parent substance of radium. Ionium, which was discovered by the American physicist Boltwood, is chemically similar to thorium, but stands between uranium and radium in the radioactive series. It has a half period of 3,000 years, and emits the slowest Alpha rays known, which penetrate only about one inch into the air and therefore sharply define the point at which the potential is measured. The ionium used in these collectors is furnished gratuitously by Prof. Giesel.

Fig. 2.—Ionium Collector (Actual Size).

Fig. 2 shows one of these ionium collectors in its actual dimensions. The ionium is strewn, as a fine powder, on an enameled disk of copper, and is crossed by platinum wires soldered to the base under surface of the disk, in order to increase the conductivity. The ionium is not imbedded in the enamel but merely adheres to its surface.

Ionium collectors work somewhat more slowly than water-dropping collectors, but more rapidly than all others.

The Gyrostatic Force of Rotary Engines*

Its Nature and Significance for Aviation

By Albert Kapteyn, President of the Aviation Section of the Dutch Aero Club

Gyrostatic action is more familiar in name than in principle to the majority of laymen, and even those who have had some training in mechanics often seem to have but a superficial and sometimes inaccurate conception of the force in question. It is, however, a subject that ought to be thoroughly well understood by everyone associated with the use of rotating masses, and, above all others, pilots of aeroplanes ought to be thoroughly *au fait* with its action, because the flying machine affords greater possibilities for its demonstration than almost any other conceivable apparatus. The reason for this is obvious when we consider the nature of gyrostatic force. It is a force that comes into play when the axis or shaft of a rotating body by itself rocked from its original position. Take, for example, the propeller-shaft of a flying machine. So long as the machine proceeds in an absolutely unswerving path, the gyrostatic force of the rotating propeller, or the rotary engine if such happens to be used, remains dormant. But, for how long does an aeroplane follow an absolutely unswerving path? Scarcely for a second of time. Almost every instant it is being steered either to the right or to the left, and often it pitches in its line of flight. Every such motion rocks the axis of the propeller-shaft and brings into life the dormant gyrostatic force, the magnitude of which depends on the rapidity with which this rocking motion takes place. It is therefore obvious that the gyrostatic force will be most in evidence when the pilot is attempting to execute a very quick maneuver, such as turning about in a very short circle.

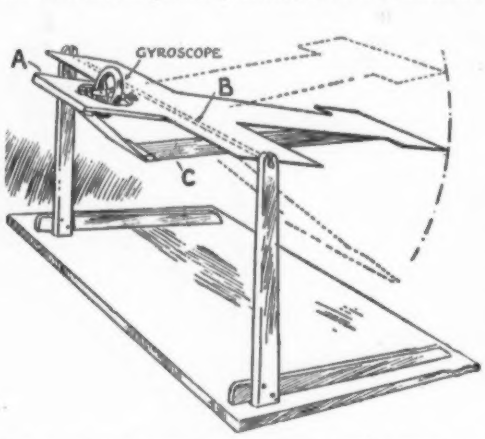


Fig. 1.—Sketch Illustrating a Simple Model That Can be Used to Demonstrate the Effect of Gyrostatic Force on the Control of an Aeroplane.

It is notorious that several fatal accidents have taken place recently under circumstances of this sort. Feeling convinced, therefore, that gyrostatic force is sufficient to cause dangerous interference with the control, and having found that many aviators are sufficiently acquainted with the principles of gyrostatic action to really enable them to appreciate when some difficulties, that they have attributed to the weather, might in reality have been due to this very force, I have thought it well to endeavor to treat the subject hereunder in simple but nevertheless, I hope, convincing terms. There is, moreover, all the more reason to treat the matter scientifically at this juncture, because nothing is so calculated to raise scepticism in the minds of those who do not know, than the very erroneous conclusions that have of late been advanced by some of those who profess to recognize the dangers of this very force. Some people seem to think, for instance, that gyrostatic action may be the direct means of fracturing main spars, struts, tie wires, or other constructional members that are not in any way directly related to the axis of the revolving shaft. It may be said at once that so far as any direct effect of gyrostatic action is concerned, the only constructional damage it is likely to do is to bend or break the propeller-shaft, and it is essentially my purpose in this article not so much to write a warning on this aspect of the case as to point out that the immediate consequence of gyrostatic action is interference with control.

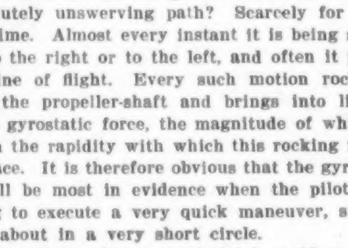


Fig. 2.—Diagrammatic Sketch Illustrating the Nature and Direction of the Gyrostatic Forces in a Spinning Disk.

* Flight.

The outstanding feature of gyrostatic reaction is that it takes place in a plane at right angles to that of the applied force and also to that of the axis of rotation of the shaft. Thus, for example, in a steamship pitching through the waves the gyrostatic reaction from a turbine shaft placed fore and aft exerts a pressure on the sides of the bearings, not on the tops and bottoms as might be supposed, and as would in fact be the case were the shaft at rest and only its ordinary inertia to be taken into account. Similarly, in an aeroplane, if it pitches in its line of flight the gyrostatic reaction tends to upset the steering, and conversely if it is steered off a straight path the gyrosatic reaction tends to make it pitch. The question as to whether the nose of the machine will tilt or dip depends on the direction of rotation of the motor and the direction in which it is steered. Suppose the aeroplane to be a monoplane with a tractor screw and that the motor has a clock-wise rotation viewed from in front; then steering to the left, *i. e.*, keeping the pylone on the left hand, will tend to make the machine dive. If the same engine is placed on a biplane so that the propeller is behind. The rotation of the shaft will have been reversed in respect to the direction of turning, consequently the machine will tend to tilt during the same maneuver.

It will be instructive to see what magnitude such forces take with machines as they may be actually constructed. For example, let us suppose that we have a powerful rotary motor, weighing 100 kilogram (220.5 pounds), driving a propeller weighing 10 kilograms (22.05 pounds) at 1,200 revolutions per minute; let us further suppose that the radius of the gyration of the motor is 0.33 meter (one foot) and that of the propeller 0.83 meter (2.72 feet). The gyrostatic reaction will have a magnitude depending on the rapidity with which the course of the aeroplane is altered in flight. We will imagine that the pilot completes an angle of 90 degrees, or in other words, changes to a line of flight at right angles to his original path, in three seconds. Wilbur Wright, it may be mentioned, frequently made such an angle in one second and less.

Applying these values, the gyrostatic couple produced by the motor is 73.5 kilogram meters (531.6 foot pounds), and that produced by the propeller is 42.4 kilogram meters (306.7 foot pounds), the combined effect being thus 116 kilogram meters (839 foot pounds). This force is a torque tending to make the machine dive or tilt as the case may be, and the principal means at the disposal of the pilot for resisting the action is the elevator. If we suppose that this member is situated 10 feet 6 inches from the center of gravity, an upward or downward thrust of about 80 pounds will be exerted upon it solely as the result of this gyrostatic force. Taking elevator planes of the sizes found on most machines, it may be stated as a rough approximation that the loading represented by such a force is approximately of the same order as that normally carried by the main planes themselves.

This gyrostatic reaction on the part of a rotating mass can be very easily demonstrated by anyone who cares to spend a few cents and a couple of hours in the construction of a rough and ready model such as is illustrated in Fig. 1. The model represents a rough approximation to a monoplane, cut out of a piece of stiff cardboard. It need not be accurate in any way so long as it has a couple of wings and some sort of a tail. Its head is stiffened by a piece of board, *A*, in which is cut a square opening to receive a gyroscope top such as may be bought for 25 cents at any toy shop. The frame of this top must be clamped down to the board so that the axis of the spinning-shaft lies fore and aft and the top is quite free to rotate. The two wings of the model are stiffened by attaching a strip of thin wood underneath them in the form of a main transverse spar, and the extremities are whittled down into a round section so that they can be mounted freely in the upright supports of the frame, which is made as shown in the sketch. To the head and the tail of the model a piece of bent cardboard must be attached, as shown at *C*, in order to bring the center of gravity somewhat under the axis of suspension. The whole must then be balanced by adding a small piece of wood to one end or the other.

As long as the top is at rest, the board on which the model is mounted can be moved across the face of a table in any direction without affecting the balance of the model, but when the top is set spinning an entirely different state of affairs exists, for directly the board is turned so as to make the model reproduce the action of steering to the right or left, the gyroscopic reaction will immediately cause the model as a whole to dive or tilt.

Fig. 3.—Photograph Illustrating How an Ordinary Toy Gyroscopic Top Can be Mounted in the Model Shown in the Sketch.

Possibly some may think that the quantitative analysis made above represents an exaggerated case, but lately some flying machines have been fitted with 100-horse-power motors weighing 100 kilograms. Furthermore, a turn at right angles in three seconds is nothing exceptional, for, as stated, Wilbur Wright often made such a turn in *one* second, and if we calculate the gyrostatic couple, for such a quick movement, on similar lines as above, we find that this couple amounts to 340 kilogram meters (2,459 foot pounds).

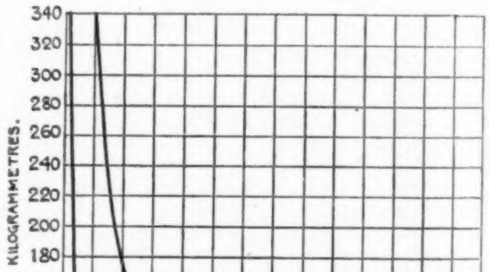


Fig. 4.—Chart Showing the Magnitude of the Gyrostatic Couple Caused by Changing the Direction of Flight to a Line at Right Angles to the Original Path in the Time Stated. Graph *A* Shows Values for a Rotary Engine Weighing 100 Kilograms Operating a Propeller Weighing 10 Kilograms, While Graph *B* shows Values for a Stationary Engine Driving a Propeller Weighing 5 Kilogrammes (11.03 Pounds) Also at 1,200 Revolutions per Minute.

On the other hand there is one aspect of the problem which makes it necessary to consider the worst case.

Even though a pilot may take precautions to the extent of not voluntarily turning too quickly, nevertheless in windy weather the action of the wind itself may force the machine suddenly to change its position and thus bring these very gyrostatic forces into exaggerated effect.

Having explained the danger, it would be incomplete not to discuss its remedy, which is that of duplicating the rotating members and making them rotate in opposite directions. It does not at present seem feasible to do this with rotary engines, but with stationary engines, where only the propellers create a gyrostatic effect of any appreciable magnitude, it is not difficult to employ two propellers rotating in opposite directions. This has been done by the Brothers Wright, and there is very little doubt in my mind that they have actually accomplished maneuvers in the air with their machine of such intricacy as could not safely be made on an aeroplane where this precaution of neutralizing* gyroscopic action has not been taken. No other pilot that I have ever seen ever executed turns and figures of eight with the same rapidity as Wilbur Wright was at one time accustomed to carry out them on his own twin-screw biplane, and I feel convinced that it is not only in the relative skill of the pilots that we must seek for the reason.

Those who may be inspired to make the little model that I discribed above, may conceivably be interested in having a mental conception of the mechanics of gyrostatic action, and although the subject is one of great intricacy in its complete elucidation there is no reason whatever why anyone should not be able to carry away a very clear idea of the actions and reactions that bring about the particular phenomena under consideration. For this purpose I have prepared a little diagram (Fig. 2) showing a spinning disk, and have supposed that the spindle, *a, b*, of the disk has been forcibly rocked over in the direction, *x*, so that it is caused to assume the inclined position illustrated. It is our purpose to investigate the forces called into being at the moment that this displacement tends to commence. Across the face of the disk I have drawn a diameter, *o, q*, representing the axis about which the spindle is turning in the direction, x, and from the point, *o*, are drawn two tangential lines, *o, r*, and *o, s*, the first named representing the direction in which a particle of the disk at *o*, was traveling before the spindle moved, while *o, s* represents the direction of the same particle after the spindle has been displaced. Now, it is very obvious that this change in direction of the movement of the particle can only have been brought about by the application of an upward force, and by Newton's laws it is equally obvious that the action has been resisted by a downward reaction, which I have represented by the line, *o, t*, on the diagram. At the other extremity of the diameter, *q*, the reaction will, for the same reason, be upward. These reactions constitute a couple, called the precessional couple, that tends to turn the disk about a line, *n, p*, at right angles to the line, *o, q*, and to the line, *a, b*, or axis of rotation of the disk. The particles of the disk at *n* and *p*, where *n, p* represents a diameter at right angles to o, *q*, do not give rise to gyrostatic reaction, because the new direction of their movement has remained parallel to their original path. From this diagram it should be quite evident that two similar disks rotating in opposite directions, but upon the same axis, would completely neutralize each other's gyrostatic reaction.

In order further to assist any readers who may be interested in this important subject, I have prepared a chart (Fig. 4) showing by means of a graph, *A*, the gyrostatic couple produced by the masses taken in the special case already discussed. The base line of the diagram represents the time taken to turn through 90 degrees while the vertical scale represents the gyrostatic couple in kilogram-meters. The lower curve, *B*, shows values for an ordinary stationary motor fitted with a single light propeller, weighing 5 kilograms, and having a diameter of 2.40 meters (7.87 feet), making 1,200 revolutions per minute.

Simple Household Inventions†

Clever Novelties from Abroad

NEW SWEEPING MACHINES.

THE last Lépine exhibition contained several interesting new devices for sweeping carpets and scrubbing floors. The simplest is the Abor broom with detachable handle (Fig. 1). This broom is designed to replace the cheap round broom of rice straw which is commonly used in France and which after a few days' use becomes one-sided and almost worthless. The Abor broom is also made of rice straw, but it is flat and the straw is securely fastened in a metal head, which is attached to the handle by a screw, so that, when the brush is worn out, it can be replaced without renewing the handle.

Fig. 1.—Abor Detachable Broom.

The Astra brush (Fig. 2) is a carpet sweeper reduced to its simplest form. Two cylindrical brushes *B*, geared to two heavy fly-wheels *V*, at the lower end of a long metal tube, are turned by a crank and wheel at the upper end, by means of an endless cord inside the tube. The brushes are easily detached and replaced by softer or harder brushes, as the work may require.

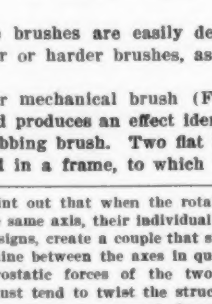


Fig. 2.—Astra Brush.

The Baranger mechanical brush (Fig. 3) is more complicated and produces an effect identical with that of a hand scrubbing brush. Two flat brushes, *A* and *B*, are mounted in a frame, to which a reciprocating movement is given by a rod connected with an eccentric. The front brush, *B*, is much wider than the following brush, *A*, the function of which is to clean depressions that the larger brush has passed over. The shaft of the eccentric, which also carries two heavy fly-wheels and a toothed pinion, is turned by means of a bicycle chain which passes over a sprocket wheel, provided with a crank, at the end of the handle. The brushes may also be operated by a small electric motor, mounted on the wheeled frame.

Fig. 3.—Baranger Mechanical Brush.

Electric power is employed exclusively in the Bruyère electric sweeper (Fig. 4), which is designed primarily for cleaning large floors in public buildings. An electric motor, *E*, connected with the mains by a flexible cable, *F*, drives a central rotary brush, the shaft of which carries an eccentric that communicates a reciprocating movement to a flat brush on each side. The machine can be moved with very little effort by means of the handle *M*, and 4,000 square feet of floor can be swept in an hour with a trifling consumption of current.

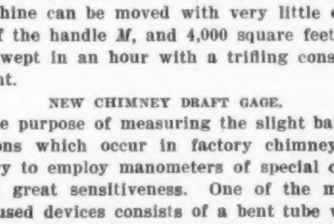
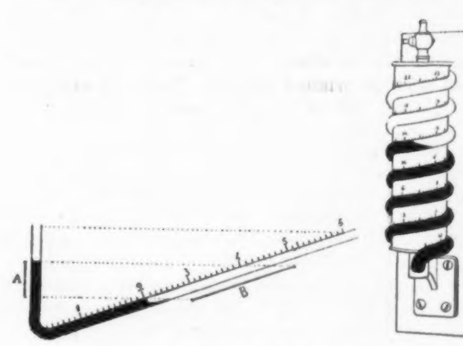


Fig. 4.—Bruyère Electric Sweeper.

NEW CHIMNEY DRAFT GAGE.

For the purpose of measuring the slight barometric depressions which occur in factory chimneys, it is customary to employ manometers of special construction and great sensitiveness. One of the most frequently used devices consists of a bent tube with one branch vertical and the other nearly horizontal (Fig. 5). A small quantity of colored liquid is placed in the bend of the tube, of which the vertical branch communicates with the chimney and the inclined branch with the external atmosphere. The variations of level in either branch rarely exceed 2 inches, but the movement of the liquid surface along the inclined branch is very much greater, so that the variations of pressure can be easily and accurately read from a scale attached to the tube.

This and the other devices in use are bulky and easily broken. An American inventor has devised the expedient of coiling the inclined branch of the tube round the vertical branch in the form of a helix, thus constructing the strong and compact apparatus shown in Fig. 6. The scale follows the helix and, in order to read it throughout, the apparatus must be visible from all sides. Even this slight inconvenience could be eliminated by making the rear portions of the outer tube horizontal, but this would be useless. In practice, it is sufficient for the regulation of the draft to note whether the end of the column of liquid is at the left or right side of a visible segment of the tube or in the invisible segment between two visible segments, the scales of which can be read.

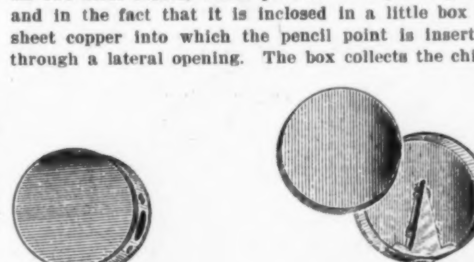


Figs. 5 and 6.

New Chimney Draft Gage.

IDEAL PENCIL SHARPENER.

The new Ideal pencil sharpener differs from other small devices of its class in the excellent quality of its two steel blades, which produce a very fine point, and in the fact that it is inclosed in a little box of sheet copper into which the pencil point is inserted through a lateral opening. The box collects the chips and dust, thus protecting the carpet and the operator's fingers from soiling. The box has a removable cover and can be emptied and cleaned whenever it is convenient to do so.



Closed.

Open.

Fig. 7—Ideal Pencil Sharpener.

* We would point out that when the rotating members are not located on the same axis, their individual gyrostatic forces, being of opposite signs, create a couple that stresses the framework of the machine between the axes in question. Thus, for example, the gyrostatic forces of the two propellers on a Wright biplane must tend to twist the structure, which is, of course, sufficiently strong to prevent damage, although the algebraic sum of the two forces, as effecting the control of the machine, is zero.—The Editor of *Flight*.

† Compiled from *La Nature*.

A Scale for Measuring the Merit of English Writing

Quantitative Estimation of Literary Style

By Edward L. Thorndike, Professor of Educational Psychology at Teacher's College, Columbia University

One inch may be said to be equal to another inch from any one of three lines of evidence. If the two are compared by a hundred experts, (1) the experts will all report the two as indistinguishable; or (2) if some of them do, by microscope, micrometer or the like, find a difference of a trifle plus or minus the number finding the first inch plus will equal the number finding it minus; or (3) if each man is forced to report a difference, half will find the first inch plus and half minus.

One specimen of English writing may be said to be equal to another from the second or third lines of argument, the only logical difference between equating the two lengths and equating the two specimens of writing being that the variability of expert judges in the latter case is so great that we never find all of them, and rarely find many of them in agreement, as to the indiscernibility of any difference. But specimens 571 and 220 below are, in merit as defined by, say, 100 competent persons, approximately equal, since if asked to report 571 as better, equal to, or worse than 220, there will be a large proportion of equals and the judgments "better" will approximately equal the judgments "worse." Of 110 competent persons, forced to make a distinction, 54 favored sample 571 and 56 sample 220.

571. Venus of Melos.

In looking at this statue we think, not of wisdom, or power, or force, but just of beauty. She stands resting the weight of her body on one foot, and advancing the other (left) with knee bent. The posture causes the figure to sway slightly to one side, describing a fine curved line. The lower limbs are draped but the upper part of the body is uncovered. (The unfortunate loss of the statue's arms prevents a positive knowledge of its original attitude.) The eyes are partly closed, having something of a dreamy languor. The nose is perfectly cut, the mouth and chin are molded in adorable curves. Yet to say that every feature is of faultless perfection is but cold praise. No analysis can convey the sense of her peerless beauty.

220. Going Down with Victory.

I sat on the top of a mail-coach in Lombard Street impatiently awaiting the start. 'Twas the night of the victory and we would help spread the news over England.

Up jumps the coachman followed by the guard, an instant's preparation, a touch of the lash and we are off! We are soon past the limits of the city out in open country, galloping, tearing along, a clear road ahead of us, for the English Mail stops for nothing.

We dash in at villages, stopping but a moment with the mail, shouting the news of the victory and we are off again. Proud were we and had we not a right to be? The first to carry the great news through the land!

The memory of that ride is ever fresh in my mind and I will ever remember those hours as the most glorious in all my life.

The difference between 1 inch and 2 inches is said to be equal to the difference between 2 inches and 3 inches, because the experts will, as before, all agree or divide equally in their disagreement. The essential logic of their procedure will appear if we change the illustration.

Let their task be to examine the following pairs of lengths: I. (*a*) 10.0000 inches, (*b*) 10.0001 inches, II. (*c*) 10.0001 and (*d*) 10.0002, III. (*e*) 10.0001 and (*f*) 10.0003, IV. (*g*) 10.0001 and (*h*) 10.0004, V. (*i*) 10.0001 and (*j*) 10.0005, and to judge in each case whether the second line of the pair is shorter, equal, or longer. We shall find that even the experts make some wrong judgments with these very small differences, but that the proportion of right judgments increases as the difference increases, so that we can conclude that the difference between (*a*) and (*b*) is equal to the difference between (*c*) and (*d*), not because it is always judged so, but because it is *equally often* judged so by experts. The basis for the scientific acceptance of a difference may then be that judgments of longer are more frequent than judgments of shorter. And the basis for the scientific acceptance of one difference as equal to another difference may be that the preponderance of judgments of longer is equal in the two cases. This is not the whole truth of the matter in the case of the equality of such differences as 1.0011 inches-1.000 inch and 1.0002 inches-1.0001 inches; but it is a part of it.

This part of it may be made true of judgments of differences in merit in English writing. For instance, Specimen 627 is judged to have more merit as writing by young people in their teens than specimen 570 by 83 out of 110 competent persons. Specimen 570 is also judged to have more merit, similarly defined, than Specimen 603 by 82 out of the same 110 competent persons. The difference between Specimens 627 and 570 is then approximately equal to the difference between Specimens 570 and 603.

627. A Scene.

I think the sunlight is very beautiful on the water, and when it shines on the water it is very beautiful, and I love to watch it when it is so beautiful. The colors are so pretty and the noise of the water with the sunshine are so attractive in the sunshine I wonder do other people love to watch the water like I do. I don't know as there is anything as lovely as the water waves in the sunlight of the glorious orb.

570. Description of School Room.

Our school room is on the side of the school house and it is a awfully nice room and I like it because it is so nice and all the boys like it, there is a good many pictures on the wall and there is a clock on the wall. We like this school room and come to school most all the time.

603. A Character Sketch.

The man I am describing is a white man and he has nice hair and wears a hat, and his horse is black, I like this man and he has two eyes and his nose is red.

In this way it would be possible to discover specimens of English writing ranging from Specimen 607 (which may roughly represent zero merit in English writing by young people in their teens) up to the best writing known, by equal steps, so that Specimens 0, 1, 2, 3, 4, and so on, would have, in part, the significance for merit in English writing that 0 inch, 1 inch, 2 inches, 3 inches, and so on have for length.

607. Sketch.

I words four and two came go billa guni sing hay cows and horses he done it good he died it goon I want yes sir yes sir oxes and sheeps he come yes sir camed and goes billum gumum oomunn goodum.

Such a series of specimens representing defined degrees of merit in composition would be of service to civil service examiners, college entrance examination-boards, high-school teachers of English, and any others who were concerned with measuring ability to write English, the changes produced in that ability by various forms of training, or the differences in it that distinguish certain groups.

An investigation designed to establish such a scale is now being made by Mr. M. B. Hillegas and myself. We should be very glad if any of the readers would co-operate to the extent of sending us their ratings of the ten specimens printed below. All that is required is that the reader consider these as specimens of English writing by young people, choose the one that seems to him to have the least merit, number it 1, choose the one that has next least merit, number it 2, and so on, and send the record to M. B. Hillegas, Bureau of Education, Washington, D. C., or E. L. Thorndike, Teachers College, Columbia University, New York. For this purpose the following slip may be used:

I rank specimen 94 as
" " 196
" " 200
" " 300
" " 323
" " 434
" " 519
" " 520
" " 534
" " 627
Signed. ....

94. Sulla as a Tyrant.

When Sulla came back from his conquest Marius had put himself consul so sulla with the army he had with him in his conquest siezed the government from Marius and put himself in consul and had a list of his enemys printy and the men whoes names were on this list we beheaded.

196. Ichabod Crane.

Ichabod Crane was a schoolmaster in a place called Sleepy Hollow. He was tall and slim with broad shoulders, long arms that dangled far below his coat sleeves. His feet looked as if they might easily have been used for shovels. His nose was long and his entire frame was most loosely hung to-gether.

200.

My dear Fred,—

I will tell you of my journey to Delphi Falls, N. Y. There is nice scenery along this route. The prettiest scene is in the gulf which is quite narrow, a small creek flows down it and the road follows along near its banks.

There are woods on either side, these trees look very pretty when they are white with snow.

In summer it is always shady and cool in them and the small fish may be seen darting back and forth in the water.

I hope I will have the pleasure of taking you over the route some time. Yours sincerely,

300. The Preacher of Auburn.

The most popular man of Auburn was the preacher. Although he had a very small salary he was contented. The preacher was kind to everybody. Little children loved him. Old soldiers liked to sit by his fireside and tell stories of the battles, which they had fought in. The beggars who came to his door, although chided for leading such an existence, were always clothed and feed.

The preacher was always willing to go to the homes where there was sickness or death. Here he helped in all things that he could.

In the church he preached with unaffected grace, and all who came to scoff at him remained to worship.

The minister was a contented, simple and kind man, whom the people loved.

323. Essay on Burns.

As far as I can learn from the Essay on Burns, Mr. Carlyle considers that good poetry must contain the sincerity of the poet. The poem must show the author's good choice of subject and his clearness of sight. In order to have good poetry the poet must be familiar with his subject and his poem will show it.

The characteristics of a great poet, in Mr. Carlyle's opinion, were sincerity and choice of subjects. A poet must be appreciative of nature and have a responding heart. Carlyle says a true poet does not have to write on subjects which are far away and probably come from the clouds. A truly great poet makes the most of subjects which are familiar to him and close to earth, as Burns did in his poems to the Field Mouse and to The Daisey.

434. A Diary.

I had an early run in the woods before the dew was off the grass. The moss was like velvet, and as I ran under the arches of yellow and red leaves I sang for joy, my heart was so bright and the world was so beautiful. I stopped at the end of the walk and saw the sunshine out over the wide "Virginia meadows."

It seemed like going through a dark life or grave into heaven beyond. A very strange and solemn feeling came over me as I stood there, with no sound but the rustle of the pines, no one near me, and the sun so glorious, as for me alone. It seemed as if I felt God as I never did before, and I prayed in my heart that I might keep that happy sense of nearness all my life.

519. De Quincy.

First: De Quincy's mother was a beautiful women and through her De Quincy inhereted much of his genius.

His running away from school enfluenced him much as he roamed through the woods, valleys and his mind became very meditative.

The greatest enfluence of De Quincy's life was the opium habit. If it was not for this habit it is doubtful whether we would now be reading his writings.

His companions during his college course and even before that time were great enfluences. The surroundings of De Quincy were enfluences. Not only De Quincy's habit of opium but other habits which were peculiar to his life.

His marriage to the woman which he did not especially care for.

The many well educated and noteworthy friends of De Quincy.

520. A CHARACTER SKETCH.

They were in fact very fine ladies; not deficient in good humor when they were pleased, nor in the power of being agreeable when they chose it, but proud and conceited. They were rather handsome, had been educated in one of the first private seminaries in town, had a fortune of twenty thousand pounds, were in the habit of spending more than they ought, and of associating with people of rank, and therefore entitled to think well of themselves and meanly of others.

534. FLUELLEN.

The passages given show the following characteristic of Fluellen: his inclination to brag, his professed knowledge of history, complaining character, great patriotism, pride of his leader, honesty, revengeful, love of fun, punishment of those who deserve it.—*Nature.*

The Electron Theory Simply Explained

The Wonders of the Microcosm of the Molecule

Lindley Pyle, A. M., Assistant Professor of Physics, Washington University

THE average person thinks in tens, hundreds, thousands. He speaks of a million, yet his mind cannot grasp its significance except by breaking it into groups and thinking of it as a thousand thousand, or ten thousand hundred. Thus, a million people live in one hundred cities of ten thousand population each. Can you conceive of a million things grouped on a needle point? Or a million million? This article aims to bring home the reality of such little things, for of these the universe is made.

The atom is the building block of chemical compounds. The chemists have discovered upon our earth about eighty kinds of such building blocks—the eighty elements, so called. We conceive of a "sodium" block and a "chlorine" block coming together to form a little structure which we call a molecule of "sodium chloride." Millions of millions of these little structures, all alike, form in the aggregate the grain of salt with which we season our food. Again, one building block of hydrogen and one of chlorine form a molecule of hydrochloric acid. We conceive of building blocks, or atoms, combining with others of the same kind to form little structures, or molecules, of that particular element. For instance, we have found that two atoms of hydrogen form a molecule of hydrogen. But how does one atom attract and hold another to form a more or less stable molecule? How does the hard rubber of one's fountain pen, after friction, attract and hold to itself bits of lint and other light bodies? We trust to the future for the explanation. Meanwhile we call it "electrical attraction," because we find the atoms electrically charged when torn from each other's grasp.

The modern atomic theory regards the atom as the smallest aggregation of stuff that enters as a unit into chemical reactions, just as a brick is considered the unit in the construction of a wall. Now, one hundred years after the adoption of the atomic theory, scientists have discovered that this atomic unit is made up of smaller units. This discovery, of course, in no way demolishes the atomic theory; the atom is still the brick unit that builds the wall, even though the brick be built of grains of sand and clay. The atomic theory is still a guiding star of chemical research.

When hydrochloric acid gas is allowed to dissolve in water, the hydrogen and chlorine atoms associated in the molecules dissociate, in great part, and move independently hither and thither in the solution, forming meanwhile only momentary reunions. In this dissociated state the atoms of chlorine are found to be negatively electrified, the atoms of hydrogen positively electrified. (A body in the electrical state of an ebonite comb rubbed with flannel is termed "negatively electrified;" in the electrical state of glass rubbed with silk, "positively electrified.") In this charged state the atoms are termed *ions*. If two wires connected to a battery of a few volts pressure are now dipped into the solution, the hydrogen ions move toward the negative wire, lose their charged state and, bubbling up, escape as ordinary molecular hydrogen, two atoms, or discharged ions, forming one molecule of hydrogen. The chlorine ions move to the positive wire, lose their charge, and escape. Such is the modern theory of electrolysis. The striking thing is that the hydrogen and chlorine atoms will carry, numerically speaking, equal charges of electricity. A hydrogen ion carries the same charge as a silver ion, as a sodium ion, and as a potassium ion. There seems to be here some sort of fundamental electrical unit. Our suspicions are strengthened when we find that nickel and zinc and oxygen ions all carry just double the quantity of electricity that the hydrogen ion carries. In fact, the ionic charge is always found to be some simple multiple of the hydrogen ion charge.

The electromagnetic unit in which we measure quantities of electricity is that quantity of electricity transferred by an electric current of one ampere flowing for ten seconds. A 16 candle-power, 110-volt, carbon-filament, incandescent lamp requires one-half ampere at full candle-power. One electromagnetic unit of quantity of electricity passes through such a lamp in twenty seconds.

Experiment shows that one-half ampere, the current required to burn the above-mentioned lamp, will in 193,100 seconds liberate one gramme[1] of hydrogen from a solution of hydrochloric acid. In other words, one gramme of hydrogen transfers 9,655 electromagnetic units of quantity of electricity. If there be n atoms in a gramme of hydrogen, each atom carries, while an ion, $1/n$ of 9,655 units, while the mass of each ion is $1/n$ of a gramme. The ratio of the carried charge to the mass of the carrier, indicated usually by e/m, is then 9,655.

It is well known that in the Crookes vacuum tube, or X-ray tube, we meet again with carriers of electricity. Negatively charged particles are shot off from the negative electrode of the highly exhausted glass bulb when its sealed-in electrodes are connected to the terminals of a high voltage induction coil. But while the velocity of ionic carriers in electrolysis may be only a few inches an hour under ordinary conditions, the velocity of the carriers in the Crookes tube may attain fifty thousand miles a second. Careful experiments by J. J. Thomson, Bucherer, Wolz, and others show that these high-speed particles, termed electrons, carry individually the same electrical charge e as a hydrogen ion in electrolysis, but that the ratio of the charge carried to the mass of *this* carrier, e/M, is about 17,670,000. This can mean only that the mass M of an electron is to the mass m of a hydrogen ion as 9,655 is to 17,670,000, or as 1 to 1,830. These numerical results strengthen our belief in a fundamental unit of electricity, but lead in addition to the startling conclusion that there exist particles of matter only about one eighteen hundredth of the mass of the hydrogen atom. And the hydrogen atom was, up to this discovery, the smallest mass of matter known to science. Moreover, experiment shows that this electron always turns out to be the same kind of a thing, regardless of the metal that forms the negative electrode, and regardless of the kind of gas that was last within the vacuum tube. It would seem that we have fallen upon the primal stuff of which atoms are made.

It is opportune to remark that when these flying electrons are stopped in their flight they set up in the all-pervading ether the shock that constitutes the penetrating X-ray.

In 1896 Becquerel uncovered the first of those far-reaching discoveries of a new property of matter, radio-activity. The striking behavior of the well-known elements uranium and thorium led to the discovery of new elements, radium and actinium. It is now known that the atoms of these elements are breaking up, exploding if you will, and are spontaneously throwing out positively and negatively electrified particles and X-rays as well. We recognize the negatively charged particles as electrons, identical in all respects with those of the Crookes tube, except that their velocities are even greater. The accompanying X-rays are particularly powerful, especially in the case of radium, with which shadow-graphs may be made through one foot of solid lead. The rays originate in the sudden starting and stopping of the electrons. And what are the positively charged particles? For years scientists waited a definite answer, and when it came gasped with astonishment. They are charged helium atoms. And helium is a well-known element, as elemental as iron or silver! Helium is a part of the wreck of the exploding atoms of these radio-active elements, and constitutes only one of many elements born of that disintegration.

It is here that Rutherford has carried out ingenious experiments that have won the admiration of his scientific brethren. He has shown how to detect the presence of a single one of these positively electrified particles, immeasurably too small to be seen, noiselessly flying faster than ten thousand miles a second. Without making any attempt to describe his apparatus in detail, it may be said that the particle enters, through a small hole, a partially exhausted vessel where, by virtue of its destructive velocity, it tears apart into positively and negatively charged ions perhaps one hundred thousand of the gaseous molecules therein, thus permitting a battery to send a momentary current of electricity through the containing space, just as a battery can send a current through a solution of dissociated hydrochloric acid molecules. Thus the invisible projectile closes for a brief instant the gap in the electrical circuit, and a current-measuring instrument in the line records a corresponding throw. Watching the instrument, this master experimentalist can say, "I have trapped *one* helium atom! *Two* helium atoms! *Three!*" One is mute at the wonder of it.

By measuring the total electric charge carried by a counted number of these helium atoms, Rutherford found that each atom bore an electrical charge of 0.0000000000000000000310 electromagnetic units. The delicacy of the method insures the accuracy of these figures. This quantity is known to be double the fundamental unit of electricity, that is, twice the charge carried by a hydrogen ion in electrolysis. In other words, two hydrogen ions can carry together the quantity of electricity indicated by the figures. But two hydrogen ions, when discharged, unite to form one molecule of hydrogen. It is a high school experiment to show that one gramme of hydrogen carries 9,655 electromagnetic units of electricity. If one molecule of hydrogen can carry 0.0000000000000000000310 units, how many molecules are required to carry 9,655 units? Evidently 311,000,000,000,000,000,000,000. These figures represent the number of molecules in one gramme of hydrogen. Since one gramme of hydrogen at standard conditions, i.e., under the normal atmospheric pressure and at the freezing temperature of water, occupies 679 cubic inches, one cubic inch of hydrogen gas must contain 458,000,000,000,000,000,000 molecules. Under similar conditions of pressure and temperature, equal volumes of different gases contain the same number of molecules, so that the above number represents the number of molecules in a cubic inch of air, or any other gas, under standard conditions. The calculation of this fundamental constant of gases is reliable. It depends upon the measurement of the fundamental electrical charge. And has not Rutherford actually counted the flying carriers, "One! Two! Three!" and caught and measured their load? Millikan, by an independent method, has obtained very recently a most striking confirmation of Rutherford's figures.

If there exist the above number of molecules of air in a cube one inch high and broad and long, the average number of molecules side by side along one edge must be the cube root of this number, or 7,710,000. The average distance apart of the molecules is then the reciprocal of this, but the diameter of the molecule is much smaller. Though the population of the cube may seem dense, the inhabitants do not touch elbows, except at intervals, as they dart about. Taking the population of our earth as fifteen hundred million individuals, it should be noted that the molecular population of a cubic inch of air is numerically the same as 305,000,000,000 worlds like ours. And the molecules may be considered crowded only when the air is liquefied, in which condition it is nearly a thousand times more dense than under standard conditions. Each cubic inch of liquid air then contains one thousand times 458,000,000,000,000,000,000 molecules. The diameter of a molecule must be approximately 0.000000013 inches. Eighty million side by side to span an inch!

It is a simple calculation to find the mass of the hydrogen atom and of the electron. Referring to the number of molecules in a cubic inch of hydrogen under standard conditions, and knowing that one cubic inch of hydrogen has a mass of 0.001472 gramme, a simple division yields the mass of the molecule. One-half this value is the mass of the hydrogen atom, which experiment shows is eighteen hundred and thirty times

[1] One avoirdupois ounce is equivalent to 28.4 grains.

the mass of the electron. Dividing by this last number, we obtain the mass of that ultimate speck of matter, so infinitesimally small that the masses of 1,140 million million milion million of them total one gramme. Thus far we are on sure ground.

J. J. Thomson concludes from theoretical and experimental considerations that the diameter of the electron is about 0.00000000000008 of an inch. Kaufmann considers that its mass arises entirely from its negative charge. The theory is that the electron is not a "something" negatively charged, but is a negative charge, and that its mass is due to the ether dragged along with the charge. What this negative charge, or electron, may itself be, the coming years must solve. It is doubtless some ethereal manifestation. At any rate, these electrons enter into the structure of atoms, but whether the mass of the atom is entirely due to the mass of its electrons, is another problem for the future. Matter may be entirely electrical.

Many scientists are beginning to think that the negative electron is the only electricity—that positive electrification means only a lack of electrons. Thus, the positively charged helium atom is merely a helium atom that has temporarily lost two of its proper number of electrons. Experimental work published recently by Nipher seems to establish this single-fluid theory. This is a return to the theory of Benjamin Franklin. Nipher's work makes it practically certain that an electric current through a wire consists of a stream of electrons traveling in a direction contrary to the heretofore arbitrarily chosen direction of current flow. Hence, any so-called electric generator, be it dynamo, battery, plate machine, or thermo-couple, is then merely a device that sets in motion electrons already existent in the circuit, the negative terminal being the pressure side, the positive terminal the exhaust side of the device.

Knowing the quantity of electricity passing through a given circuit, and knowing the uniform charge carried by an electron, an interesting calculation may be carried out. It has been stated that one electromagnetic unit of electricity passes in twenty seconds through the ordinary 16 candle-power, 110-volt, carbon-filament incandescent lamp when burning full candle-power. Therefore, in one second, the stream of electrons which constitute the current transfer through the filament one-twentieth of an electomagnetic unit. Each electron carries a charge just half that measured by Rutherford for the helium atom, or 0.000000000000000000155 electromagnetic unit. The quotient of one-twentieth by this number is 3,230,000,000,000,000,000, or the number of electrons which pass *in one second* any given point in the filament. The molecular agitations set up by this flying horde constitute the heat developed and give rise to the light emitted. To force through this lamp a mass of electrons equivalent to the mass of one pound would require five thousand years. Remembering that over three million million million electrons enter, or leave, the filament per second, the mind appreciates for the first time how minute the electron is.

From a wealth of evidence we know that the electrons in an atom swing around the structure like the planets in a solar system, some of them completing a revolution in a millionth or a billionth of a second. When we know to a certainty what keeps them in their orbits, we shall know whether they alone make up the atom. Recall that the diameter of a molecule is of the order of 0.000000013 of an inch, while the diameter of an electron is estimated at 0.00000000000008 of an inch. The diameter of a molecule would appear to be nearly two hundred thousand times the diameter of the electron. The diameter of the electron may be only one hundred thousandth of the diameter of its atom and of its orbit! By a peculiar coincidence, the planet Uranus, of diameter thirty-two thousand miles, revolving in its orbit of diameter thirty-six hundred million miles, pictures this ratio for the harassed imagination.

And these electrons light our streets, and drive our cars, and send our wireless messages! Are they the stuff that built matter? Then what builds them? These secrets they must tell.

Pearls Ordinary and Extraordinary

Everybody is familiar with the precious pearl and its mode of origin. Much less well known is the fact that pearls of a kind are also found in various plants and animals. An article from the pen of Dr. Emil Carthaus in the *Gartenlaube* brings some interesting information regarding the subject. A brief resume of Dr. Carthaus's paper may interest our readers.

"In view of the high value which is attached to pearls as a gem of great beauty, many ingenious heads have from early times busied themselves with the problem of their mode of origin within the shell of ungainly shellfish. Meanwhile, the fact has passed almost unnoticed that occasionally, though indeed rather rarely, such pearls are formed in plants and also in vertebrate animals. It is true that even Pliny speaks of these remarkable cases, but later naturalists have never seriously given any attention to the matter, and perhaps have not even credited their existence.

"One German naturalist of the middle ages, however, Rumphius, towards the end of the seventeenth century made some very valuable contributions to the exploration of the fauna and flora of the Indian Isles, and among other things collected with much care as many of these remarkable stones of animal and plant origin as he could. These concretions are called mesticas by the natives, probably after the Malay word "Mutiga," for pearl, and are highly prized as lucky talismans. The authentic mesticas which have come to the notice of the writer were almost without exception formed in cocoanuts or in the tissue of the thick, juicy stems of banana trees.

"Rumphius also describes true vegetable pearls, formed in the wood of the cocoanut palm and certain other related trees. The mesticas formed within the tissue of plants are round or oblong and in rare cases reach the size of a pigeon's egg. Most of them are white in color, but lack the luster of true gem pearls. It is stated that all true mesticas will produce a spark when struck with a hard stone in the dark. This is somewhat remarkable inasmuch as most vegetable pearls, like the oyster pearl, are composed of calcium carbonate, whose hardness is not sufficient to give a spark with steel. It would seem that this is a case of fluorescence of phosphorescence, ascribable, perhaps, to the presence of fluorine or calcium phosphate.

"Some vegetable pearls consists of silica. These may be formed either in the plant itself (they are not infrequently found in rice grains), or they may be produced during the rapid decomposition of hard fruits which have fallen on the ground.

"It does not appear to be at all well known in scientific circles with what extraordinary rapidity plant material can be thus petrified in the region of the Malay Archipelago, where the soil moisture is in contact with fresh volcanic tuffs, which are generally very rich in readily soluble silica. In fact, in volcanic districts of the west coast of Sumatra the Malays are in the habit of immersing timber for some months in stagnant water before using it for construction, as by this process, through the infiltration of silicic acid, the timber is rendered more durable and harder.

"As regards the mode of origin of pearls and mesticas on similar stony growths in plants and animals, the following may be regarded as the probable state of affairs. Both true pearls found in the shells of oysters, and also mesticas taken from plants and animals, represent, so far as they consist of lime, pathological and abnormal formations, so-called "concrements." In other words, they are formed by the secretion of calcium carbonate around certain organic centers. This supposition is borne out by their structure, which shows concentric layers of calcium carbonate separated by fine organic membranes. As regards the precious pearls, we know that their origin is frequently ascribable to intestinal parasites of the shell fish.

"Rumphius tells us, as a fact within his own observation, that the mesticas, which as a rule become spotted and discolored in time, can be restored by laying them for some time in the juice of unripe cocoanuts, or by rubbing them and treating them with water previously used for washing raw rice. In either case the liquid is one containing a considerable amount of starch. Stranger still, and possibly of practical interest for artificial pearl culture, is the fact well known to Indian jewelers, that true precious pearls, which have not long been taken out of the shell, will continue to grow and even show bud-like protuberances if laid for a time in rice-bran rich in starch.

"Much might be added regarding this subject, but it must suffice in conclusion to make a brief quotation of rather gruesome interest regarding the human pearl, that is to say, the mestica found in the body of a man. Rumphius says 'The Indian princes have certain signs, or rather vague indications, from which they conclude that such a stone is to be found in a given person. Then, under any suitable pretext, they have the man executed in order to extract the stone. Thus lightly do they esteem the life of a man. Having obtained possession of the stone, they carry it on their person in the belief that it will render them cunning.'"

Bones Set with Aluminium

Various means are used for setting together bones which have been badly broken, but there is much room for improvement in this direction. It is claimed by two French physicians, Mouchet and Lamy, that an aluminium socket or a band put around the bones will give very good results. Heretofore the principal methods of attaching them have been to use metallic sutures, nails, screws or clamps, but various difficulties are met with in all these cases. It is found that aluminium is a very good metal to be used in this kind of operations, and the authors state that the metal holds out the best of any when introduced into the human body. It is found that any kind of a clamp must be made somewhat heavy in order to be solid enough, and the use of an aluminium sheathing is much to be preferred as it is lighter. Pure sheet aluminium is used in this case. The two fragments of the bone are matched together and then bound by putting around them a small aluminium band, first scraping off the bone so as to give a hard under surface for the metal to bear upon. It is best to use annealed metal in this case. The band lies an inch or even two over each side of the fracture, thus forming a kind of sheath. Screws are used to fix the band in place, and these are of the same metal. The authors cite three cases of fracture which they treated very successfully in this way, and the bones were restored to their original shape so that the members could be used as before. Aluminium has several advantages for this work, as the annealed metal is soft enough to be applied tight against the whole surface and at the same time it is very strong and thus holds the parts securely together.

The Fertility of Black Earth

At different points on the globe, and especially in Morocco, south Russia and Australia, there exists a kind of black earth which is remarkable not only for its color but also for its great fertility, so that without using any kind of fertilizer the crops obtained from this land are exceptionally good, and this keeps up for many years. It is curious to note that all this ground is in plains at a low level and is very much affected by hygrometric changes of the atmosphere during the season where rains occur. In the dry season such ground is hard and full of cracks. For a long time it was thought that the earth owed its color and fertility to large amounts of humus or vegetable soil, and it was the opinion that such vegetable matter was what fed the plants during the growth. However, such large amounts of vegetable earth are not found in this case, but as it is well distributed throughout the soil this causes the black color which prevails. It is recognized at present that such vegetable matter is a source of potash, phosphoric acid and ammonia in large amounts, so that the presence of humus is indirectly a cause of fertility of the soil. For the black earth of Australia, at least, it appears that iron salts in the soil also cause a black color. Geologically, such earths can be divided into peats, basaltic, alluvion, and those of limestone origin. The first kind, of the nature of peat, is found in the marshes and along streams, and they take their color from the reducing action of their vegetable or humic matter on the oxides of iron, and this seems to be proved by the fact that in regions such as in Cumberland where the presence of sand causes silica to come into action, like soils are no longer black but of a whitish hue, and are of a very acid nature, having scarcely any lime or potash. In volcanic regions where iron minerals are abundant and the iron compounds can be oxydized, such soils have a reddish color. In the basaltic plains of Australia, the presence of lime favors the formation of vegetable earth, and it also makes the nitrification active and thus aids in the reduction of oxides of iron, so that this may explain the dark color of the soil. The earth of this region is the most fertile of all the black earth of Australia.

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